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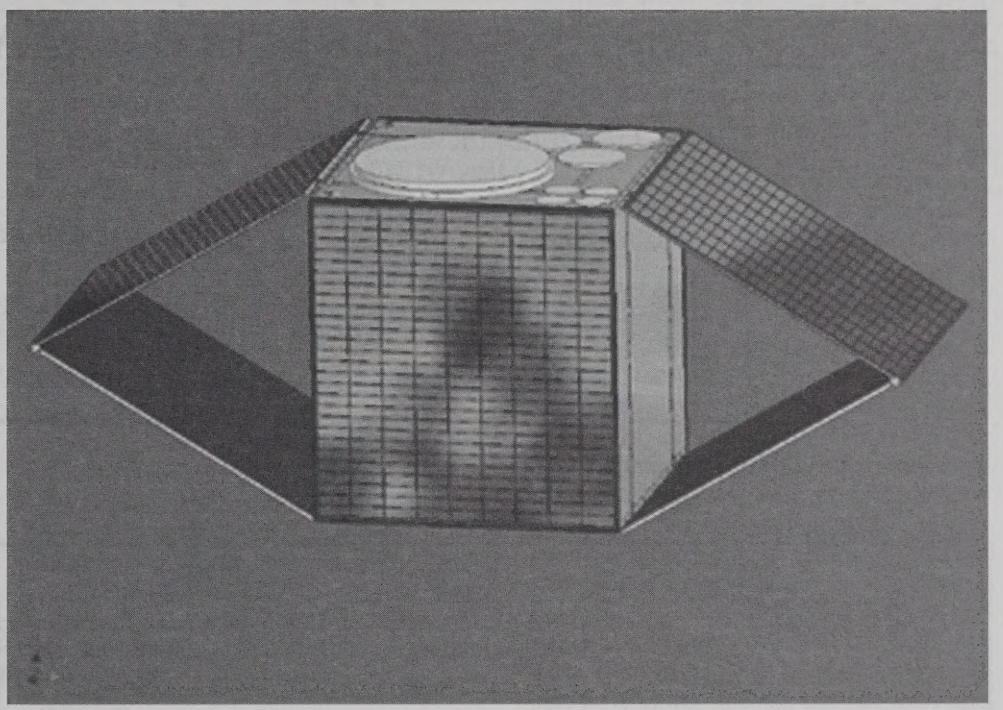

Figure 4. AMSAT Eagle with its Y-side solar panel wings spread for service. The "V" shaped deployment of these solar panels very amply provides solar power generation for all solar Beta angles.

So You Want to Build a Satellite! – Revisited

Dick Jansson, WD4FAB

Two years ago, at the Portland AMSAT forum, a new amateur satellite program was proposed. This proposal outlined a low-cost, *simple* satellite design to fulfill the future needs of the Amateur Satellite Service. Actually two designs were proposed by different authors, and they have since been merged into one program. Those proposals have moved forward into the serious design stage in a program that we now call *Eagle*. It has been discovered that not all of the initially proposed, lofty goals can be met, but the work done to date shows a considerable promise for a viable and reproducible spacecraft design. The principal goals of an all-solar-attitude, low-cost, geosynchronous transfer orbit (GTO) design have been retained and have

[continued on page 3]

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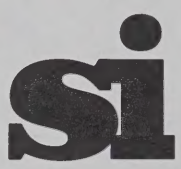

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Apogee View

During the past few months, I have become aware of several amateur satellites that are being built around the world. These satellites, if successfully launched, will provide excellent operating opportunities for AMSAT members for many years to come. The life expectancy of an *AMSAT satellite* seems to be increasing and exceeds the design life that is about seven years. As we are now aware it is even possible to have resurrection as in the case of AO-7.

Satellites under design and/or construction are *Echo* an AMSAT-NA Microsat due for launch at the end of 2003 or early 2004. This is an updated successor to A0-27 and UO-14 and the subject of *The AMSAT Journal* article in May/June 2002. *Eagle* another AMSAT-NA satellite is currently being designed and will supplement AO-40 having both mode UV (mode B) and modes US and LS available. We are now planning some additional experiments on board to confirm the results obtained on AO-40.

More details of both of these satellites will be available at the November 2002 annual meeting and in the future pages of *The AMSAT Journal*. AMSAT-ZL members are developing KiwiSat, as reported in the July/August issue of *The AMSAT Journal*. This satellite will also incorporate Mode B and our friends at AMSAT-ZL are looking for assistance from all AMSAT members around the world. Please see the article in the previous Journal and help AMSAT-ZL wherever possible.

Two satellites are being designed and developed in Australia, one by the students of the University of New South Wales in Sydney is known as Bluesat, the other is being developed by a group known as the Australian Space Research Institute (ASRI). Both satellites are in the Microsat class and will provide amateur services, which I hope will be the subject of future articles in *The AMSAT Journal*.

The AMSAT-India project (VUsat) is now well advanced and many articles have appeared in *The AMSAT Journal*, the latest being in the July/August issue 2002, this satellite is expected to be launched in 2003, with two FM beacons and three linear transponders.

In addition our friends at AMSAT-DL are planning two satellites, one known as Phase 3E will be placed launched into GTO and transfers into a higher inclination orbit. As well as standard amateur transponder, this satellite will carry experimental payloads that will be used in the second AMSAT-DL spacecraft (Phase 5A) the "MARS" mission. Although this mission is not strictly an Amateur Radio mission it is of great interest to those who are designing systems and equipment for such a mission and for those who want to carry out weak signal work. A description of this project can be found in *The AMSAT Journal* of November/December 2001 and January / February 2002 issues.

Although this listing of future satellites is very brief, it is lists eight possible spacecraft that are due for launch in the next few years with exciting possibilities for our AMSAT community. This community comprises the users and developers of groundstations and groundstation equipment, the writers of software that is involved with groundstations, the developers, designers, and builders of spacecraft and the onboard software. Last but certainly not least. There is the AMSAT member who just enjoys working through the satellites and supporting AMSAT in all of its functions.

I hope that, between all of the eight satellites, there will be something that will provide you with the impetus to keep supporting AMSAT. Looking forward to seeing you at the Annual meeting in Fort Worth.

73,

Robin Haighton, VE3FRH
President

[Continued from page 1] produced a design tailored to fit a number of launch environments. This paper will describe the work done so far, and set forth the work yet to be done.

Here We are Again

Two years ago, at the AMSAT symposium in Portland, Maine, several satellite ideas were placed on the table for your consideration (1). Since there were some *competing* concepts for our next satellite, a meeting was called in July 2001 in Denver, Colorado, to resolve those concepts into a singular effort (see September/October 2001 issue of *The AMSAT Journal*). **[Continued on page 4]**

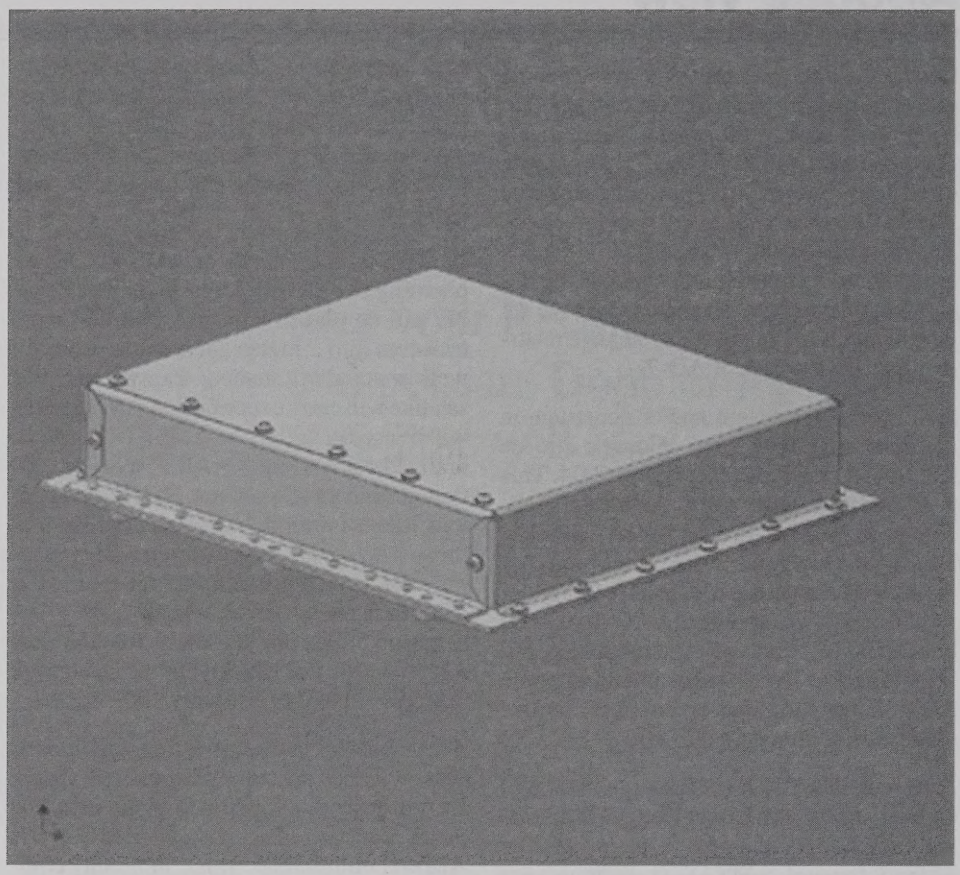


Figure 1. A *standard* module design of 200x180mm.

[Continued from page 3] At that time, we did not even have an *official* name for the program, it was called *JJ* (derived from the first letter of the family names of the authors, and a matter on which Lyle Johnson and I were both agreed had to go). This paper presents to you the results of the work done since Denver, showing a satellite design that we now call ***Eagle***, a coalescence of the not-so-different ideas that were presented to you in Portland, but a design that is felt to provide a broad tool for our use in the future. This design has the flexibility to provide service for many different applications, not just those of our amateur uses.

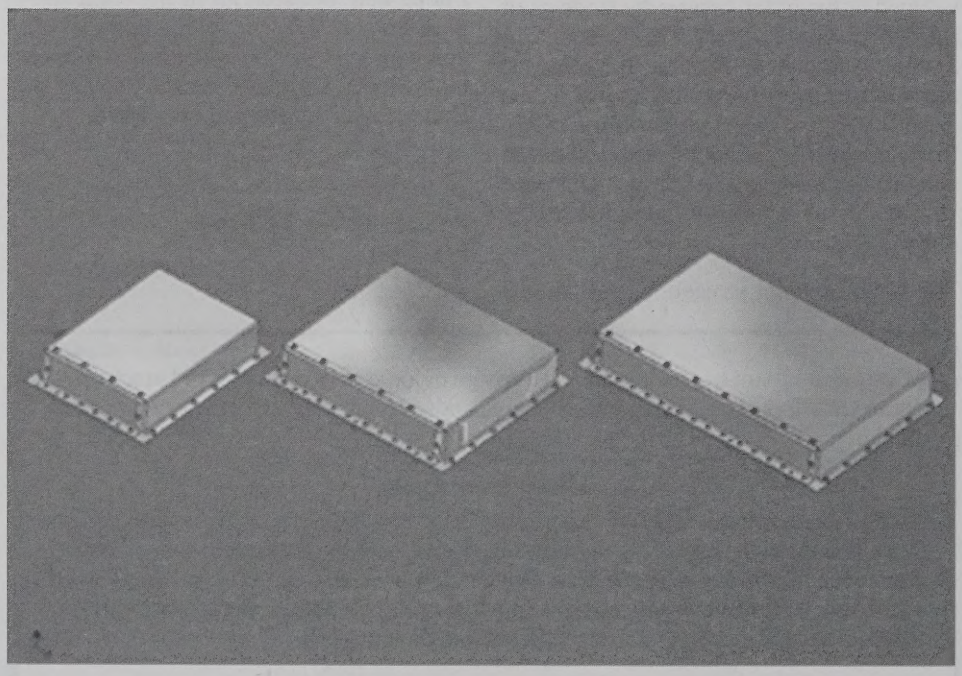


Figure 2. Three sizes of Eagle modules (l-r): 125x180, 200x180, and 275x180.

Design Goals

Let us review the basic design goals of the Eagle program. I shall do some recounting of the objectives placed on the table for you in Portland, as most of those survived the review in Denver.

We are still looking at a satellite that will provide us with the benefits of the wide-area coverage that can only be provided by high-altitude operation of the satellite, as we had in the previous OSCAR 10 and 13 (AO-10, AO-13) satellites and that we have now in OSCAR 40 (AO-40). We are still working to hold to the basic AMSAT design tenets of KISS (2) for this design. Let us look at these key points provided for this program in my prior presentation, and see how our current effort stands up to the proposed goals.

- High altitude orbit for wide area coverage and long-distance DX operations
- Transmitting and receiving equipment for wide-band, multi-user SSB operations
- No propulsion
- No more than three years from start to launch
- Cost less than $500,000
- Reuse as much prior design technology as possible
- Weight less than 50 kg

The orbital goals for Eagle are for a modified GTO (3) where we would need to lift the perigee to between 500-1000km for a stable orbit and reasonable lifetime. It used to be that an Ariane 5 launcher would provide us with a GTO that met these goals with no propulsion needed on our part. AO-40 was launched into just such an initial orbit. So much for great ideas. The newer, restartable Ariane upper stages now provide the more conventional GTO lifts to space, ending up with ≈200km perigees. So Eagle will need to carry a propulsion system, but we are working hard to select such a system that is as simple and easy to handle as is possible. Lifting the perigee of a GTO satellite does not need a large amount of propulsive energy, 30-60 m/s, so we can still keep it simple, even though we cannot avoid a propulsion system.

One of the problems seen with all of the Phase 3 satellites launched to date is that they all have been designed to operate at high orbital inclinations, and every one has failed to really achieve that desired goal. As a result, the solar power production on the satellite has been inadequate for parts of

each year of operation. To maintain minimum solar power generation, these satellite's antennas have had to be off-pointed from the Earth, pointing them away from the users at optimum operating times. Sadly, we see this with AO-40 these days; there are *seasons* of operation, at least until AO-40 is brought under its stabilized operating mode. One of the basic design features of Eagle is to overcome this very problem by providing full power operation of the system regardless of the sun-angle (Beta angle,β). This very situation is the reason that *two* basic satellite designs were offered to you at this meeting two years ago, each one solving this solar power problem in a different manner. There will be more on this point later in the paper.

The creation time of this design will not meet the initial goal of having a program that is just three years long, as another, short-term AMSAT program has intervened and drained some resources from the Eagle program. That difficulty has not slowed some of us down on the Eagle effort. However, another factor is slowing the Eagle program down, that of having a launch opportunity at hand. A launch would be available for us anytime that we would want to pay full fare for an Ariane 5 ride, but that is a $2,000,000 matter, much more than the construction phase, and more than we have readily available.

This draining of resources is costing the Eagle effort in the electronic area, and I can report that we do not yet have a stable full of electronics ready to be mounted into the spacecraft. One proposal that had been placed on the table in Denver was that of an all-digital voice mode of operation. Reality caught up with those proposers when it was realized that the ground station requirements would exceed any reasonable budget and that the satellite's resources could not support the all-digital operation.

We are meeting the goals of reusing as much of prior design technology as possible, as we have a number of the key players from the Phase 3D effort also working on Eagle, and we very well know how to borrow ideas and reuse them.

The weight issue of being less than 50 kg will easily be met with the exception that the propulsion *juice* may cause us to exceed that limit. This one is still on the table at this time. So with all of these caveats, let us dig into what Eagle looks like at this time.

Eagle Spaceframe Design

Eagle's design starts with deciding some basic mission parameters. The first is to decide by what methods that the satellite will be stabilized in orbit, so as to be able to orient the antennas in desired directions. The details of this point are what caused two designs to be offered in Portland. One design, proposed by myself, followed the past practices of orienting gain antennas, and spin axis, in the orbit plane toward the Earth with the satellite at apogee. Away from apogee, the antennas will be operated on their sidelobes, but at lower altitudes. There is a tradeoff between antenna gain and altitude that will provide nearly constant signals for Earth stations for a major part of the orbit using this stabilization and orientation method, see a later discussion on this topic. The antenna designs that would be used would employ well-known designs. The second satellite design, offered by Lyle Johnson, would maintain the spin axis perpendicular to the orbit plane at all times and employ omni-directional antennas to provide a uniform antenna pattern to Earth stations at all time. The antenna designs for multi-band omnidirectional operation had not yet been well defined, and would constitute a major prob-

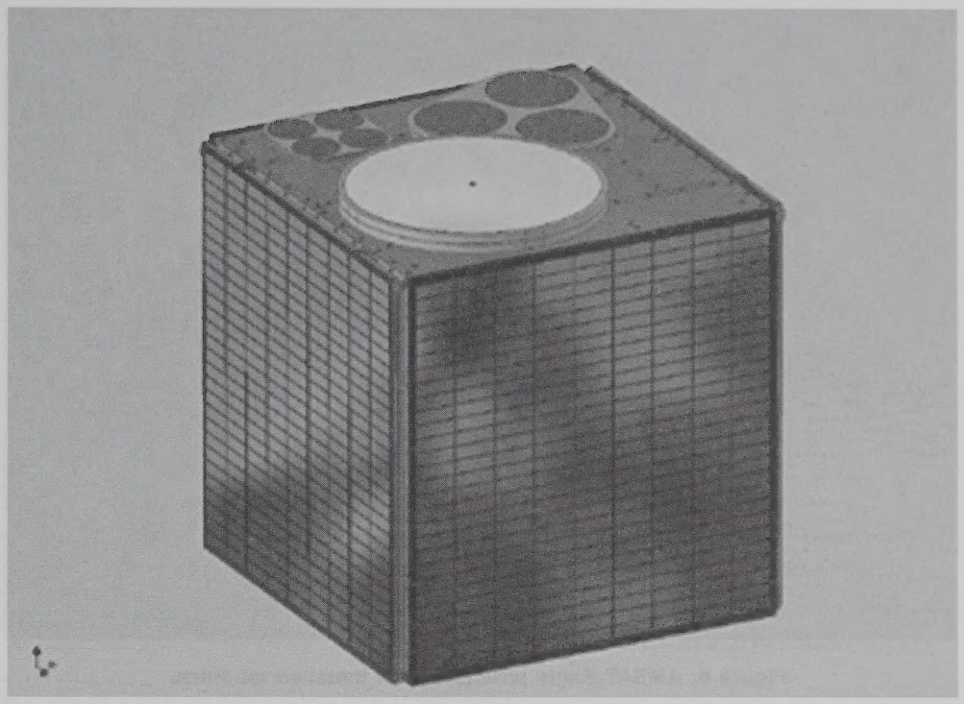


Figure 3. AMSAT Eagle in launch configuration with solar panels stowed for launch.

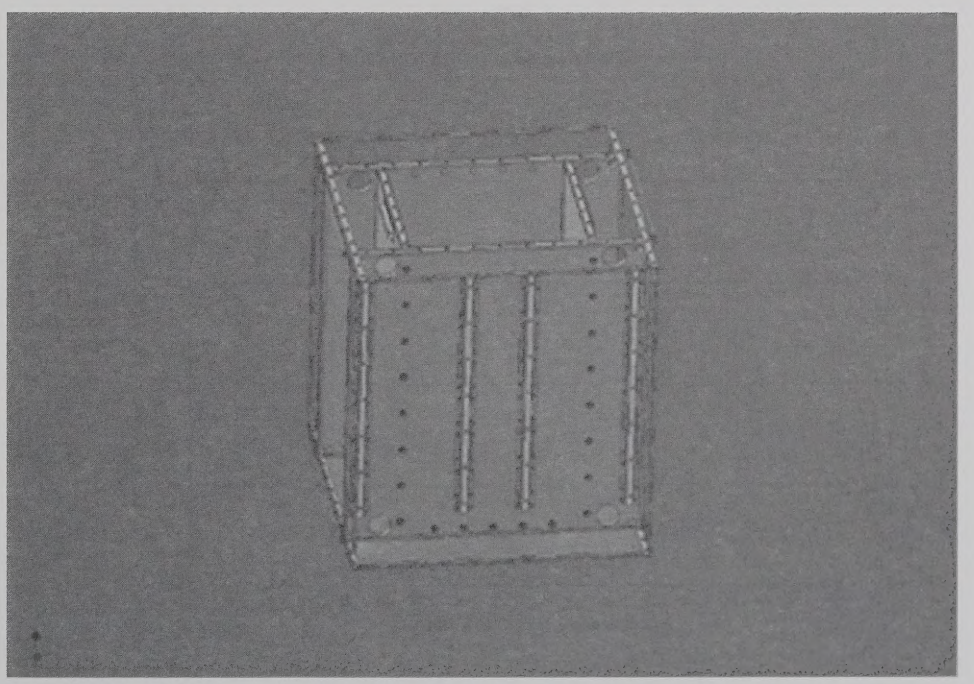


Figure 5. AMSAT Eagle structure.

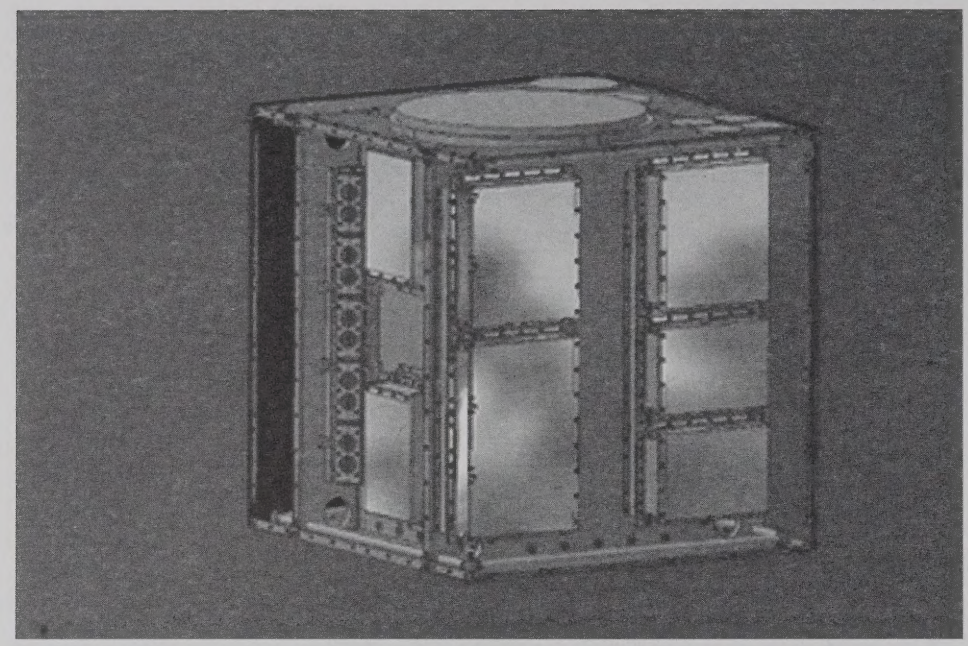


Figure 6. AMSAT Eagle structure with installed modules.

lem to this overall satellite design. The delegates at the Denver meeting agreed that Eagle should go forward with the *spin-axis-in-the-orbit-plane* concept that I had proposed. That decision was quite acceptable to Lyle Johnson, too.

Electronic Modules

Following the Denver meeting, the Eagle design really got started with the electronic module housings. Several of us (the *Orlando Gang*, Stan Wood, WA4NFY, Lou McFadin, W5DID, and myself) incorporated our operating experience with the Phase 3D modules and decided to create a design that would be easier to use. It was also decided that the module size of our thought, would be able to fit into most any spaceframe that we were likely to produce. Figure 1 shows the result of this combined experience. This module, the *standard* module design, is called a *200x180*, which is the contained PCB size in millimeters. This design is slightly smaller than the medium-size module design (195x200) used for Phase 3D, noting that electronics use less space these days. This design, like those of Phase 3D, are incremented in units of 75mm, to create larger and smaller modules, thus we have designs for a *125x180* module, and a *275x180* module (Figure 2). Each of the larger modules also comes in versions that provide for the heat sinking of power transistors.

Not yet defined are methods for stacking these electronic modules to provide added capacity and association of modules. Later you will see how these modules fit into a spaceframe. These modules all now exist in manufacturing drawings, ready to build. (We are looking for sheet metal worker-volunteers!)

Spaceframe

The next decision to be made was that of *how big* do we make this satellite design? As we do not have a slot on a launcher yet, we needed to create a design that would be most likely to fit in nearly any situation, be it Ariane, Delta or (?). It was agreed in, Denver, that this design needed to fit into a cube of 600mm on each side, sort of a universal cube. This volumetric constraint then drove the design so that (unfortunately) two sets of solar panels will need to be deployed, once in orbit, so as to achieve the all-attitude solar power generation aspect of the design. Deployable panels (moving parts!) are not in keeping with our KISS precepts, but there seems no alternative in this case. If we can launch with the panels deployed, we would like to consider that option.

Figure 3 shows this rather ordinary looking cubical design spacecraft. (After all, what can be exciting about a cube?) With the Y-side solar panels latched down for launch, Eagle just fits inside of a 600mm cube, save for antenna protrusions. On the top, +Z side of the spacecraft, you will see a director-stacked U band patch antenna, a three-patch array for L band, and a four-patch array for S band. There is room for a second S band array. Not yet shown is the antenna for V band, nor any of the omni-directional antennas needed for the initial commanding and for perigee service. There will be more discussions on the RF equipment later in this paper.

Figure 3 shows Eagle with its Y-side solar panel wings spread for service. The "V" shaped deployment of these solar panels very amply provides for solar power generation for all solar Beta angles, as will be shown later. The hardware mechanization for this deployment exists! (It is not an arm-waved design.) While it is quite cute to see it work on the computer screen, we will still need to

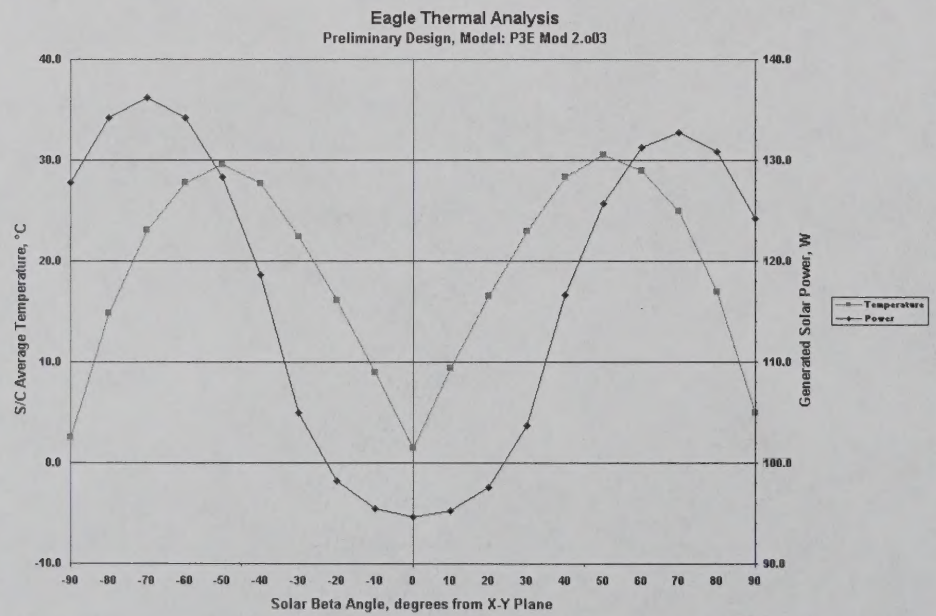


Figure 7. Results of primary thermal analysis for cell and panel arrangement.

build a full-scale model for testing of this mechanization.

Eagle consists of a core structure of commercial grade, 12.7mm thick, honeycomb panels with 0.5mm thick aluminum-face sheets. We are taking from the AMSAT experience of working with this material class in the Phase 3D program and in the Phase 4 program (which was terminated over twelve years ago). We learned a lot of the practical workability aspects of honeycomb panels in those programs. These honeycomb panels, shown in Figure 5, form a central box with four, 100mm deep compartments around the sides for the electronic modules. The central core *box* is a generous 330x330x598mm compartment to accommodate a propulsion system, which is TBD as of this writing. A simple cylindrical tank of eight gallons can be fitted into this compartment, it is not small! In this de-skinned view of the spaceframe, you are looking down on the +Z top with the +X side closest and the -Y Side to your left. For the lack of any other suitable reference at the moment, I am using these geometric notations to identify spaceframe locations.

Seen in the equipment bays is an old design element, fiberglass channels for mounting modules to the spacecraft. These are to thermally isolate the majority of the low-power electronic modules, so that their heat is dissipated only by radiation, not conduction. This thermal design feature, first used on Phase 3A (lost in 1980 due to a launcher failure) has since been very successfully proven on other Phase 3 spacecraft, including AO-40. This is also in keeping with the KISS precept of: *if it ain't broke, don't fix it.*

How do the modules look in the spaceframe? Figure 6 should give you a very good idea on this question. Shown is the spaceframe with the +X and –Y panels removed. On the +X side, there is an eclectic collection of unnamed modules (two 200x180; one 275x180; and two 125x180), showing a representation of their fit. On the back of the –X panel wall, to the left of the view, in the –Y compartment, you see one of the five-cell, (20Ahr cells) battery assemblies. There will be four of these assemblies in the spacecraft to provide a 28VDC power service, as on AO-40. Also seen are two of the 125x180 modules, the largest that can be fitted into the Y compartments with the batteries. Taking from our Phase 3D experience, a generous wiring and connector trough is placed between columns of modules on the X sides. Wiring holes are also placed near the corners of each X panel to provide for the wiring interconnections between compartments.

Also shown in this view is the magnetic

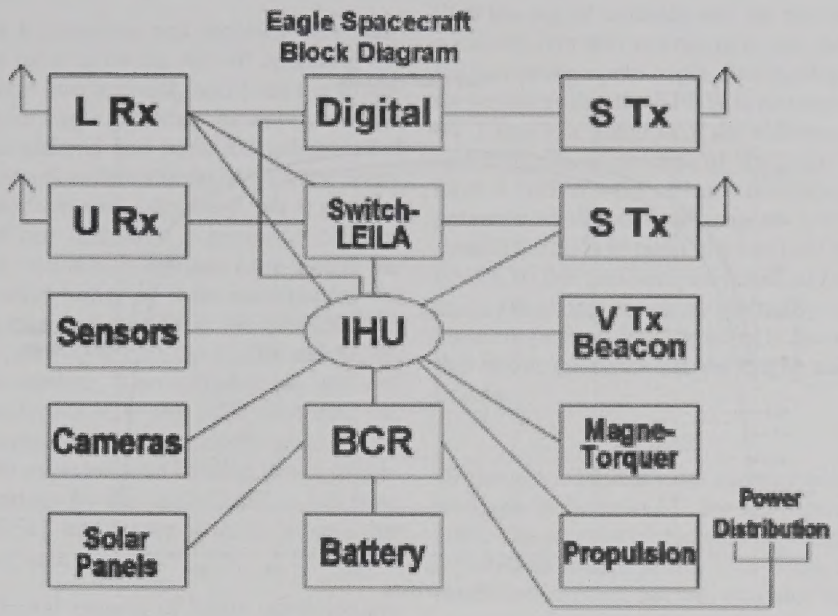


Figure 8. AMSAT Eagle Block Diagram from Denver meeting. (This block diagram is being modified based on the recent Orlando meeting and will be provide in a future article.)

torquing system, composed of two square rings of computer controlled electromagnetic coils wound on pure iron rods. These rings are located on the inside of the top and bottom panels. The coils will be used, as on all of the preceding Phase 3-mission spacecraft, to control the spacecraft spin rate and pointing angle.

Solar Power

As seen in the preceding illustrations, Eagle has six solar panels. This arrangement satisfies the design goal for generating power at any solar attitude. I have designed these

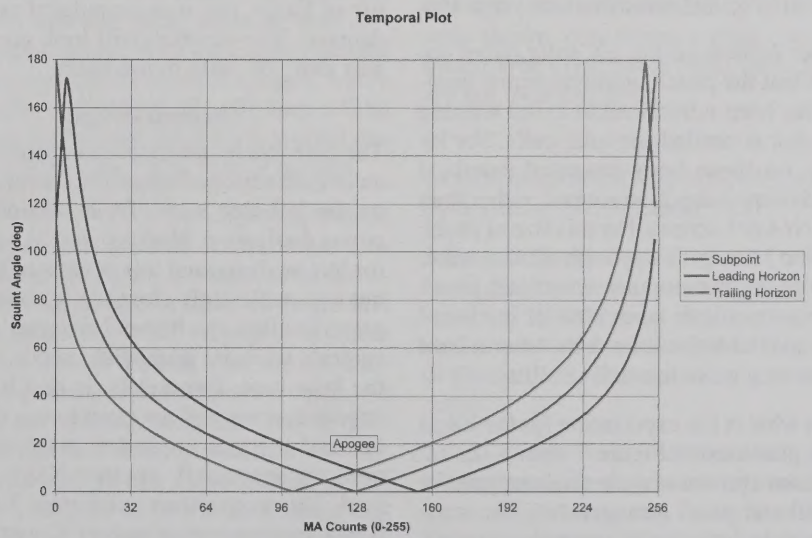


Figure 9. Squint plot showing squint angle as a function of Eagle MA counts.

Figure 10. Path loss for Eagle MA counts.

panels for just a single cell lay-down, meaning that the panels all have an identical cell design. As a generic candidate cell for this design, I have chosen a 20x60mm cell. Also for initial purposes, I have chosen the cell efficiency at a conservative value, for these days, of $\eta = 18\%$. Considerably higher efficiencies can be obtained these days, up to an astounding $\eta = 27\%$! These kinds of numbers were not even in our dreams when we designed Microsat some fourteen years ago.

Another feature on the ±X solar panel design is that the panel mounting screw hardware has been minimized to avoid wasting space that is needed for solar cells. For instance, on these body-mounted panels, I have chosen to use 2-56 screws, rather than larger Nr.4 or 6 screws. For this size of panel, I felt that I can get away with this measure, using smaller, but more screws on each panel. As a result, a little over 90% of the panel area is available for solar cells, often a hard number to achieve in small satellites.

So just what is the expectation for the Eagle power generation? Figure 7 shows the results, from a preliminary thermal analysis, for this cell and panel arrangement. The scale on the right is the solar power generation, and the curve gives power values from a low of about 95W at $b = 0°$ up to the maximum power output of up to 135W at $b = -70°$. The slight asymmetry shown between $\beta = \pm 70°$ is due to slightly different angles of the Y-axis panels on the top and bottom of the spacecraft. Nevertheless, very adequate power will be available for Eagle to use. If you consider that we may well have h = 23% solar cells, rather than the h = 18% cells, then you have to increase the analytic power values up by another 27%, so that the minimum power would be around 120W. All of these values are at the beginning-of-life, BOL, for the solar cells and that we must design for a 1/3rd lower power generation for later in the life of Eagle, due to accumulated radiation damage. The numbers still look good, any way that you want to use them.

Thermal Design

The other curve presented in Figure 7 shows an overall expected spacecraft temperature, on the left side scale, for a nominal 50W power dissipation. Nothing special was done for this analysis, and it is not a detailed one, but it is sufficiently close to the desired target as to allow the thermal designer to concentrate on more immediate needs. One of the keys here, fortunately, is that it would appear that we will not need to use the specialized thermal insulation blankets often used on spacecraft, another KISS design goal. The temperatures of Figure 7 show a $\beta = 0°$ temperature of just +1°C with maximum temperatures of +30°C at $\beta = \pm 50°$. Fine trimming of this design will probably lower the temperatures by no more than 5°C. For an initial assessment, this analysis does not show any real problems in the thermal area, allowing us to proceed with the remainder of the design. A detailed analytic model of the completed satellite will be produced in due time, allowing the fine tuning of the exterior coatings and setting the final temperature ranges of operation.

I previously mentioned a feature, used in all recent Phase 3-type spacecraft, that of providing conductive thermal isolation of critical electronic modules from the spaceframe. The reasoning for this, which was very soundly confirmed from AO-10 telemetry, is that when the spacecraft is shadowed from the Sun by the Earth, temperatures drop very precipitously, down less than -100°C, and in a hurry. Such temperatures are not good for the command and control of a spacecraft, stuff might just stop working, which would not be very cool (you should pardon the pun!). Providing a high degree of thermal isolation, especially for these usually low power C&C modules was felt to be worthy, hence the fiberglass mounting channels. This design step allows these critical modules to stay considerably warmer than the very cold spaceframe, maintaining their functionality. The AO-10 telemetry verified this concept, even to having that data overtrace the analysis made many years before that flight. Again, "*if it ain't broke, don't fix it*".

Thermal isolation concepts will need to be set aside when we consider the handling of concentrated high power dissipations, such as from the power transistors of the RF transmitters. In the Phase 3D program, which has much higher power transmitters than Eagle will see, we used a heat pipe system to redistribute that power. In Eagle we do not have the spacecraft geometry or the device dissipations that would warrant a heat pipe system. Instead, analyses have been done that show that a transmitter could just be mounted on a 6mm thick aluminum plate some 300mm square, for instance, and then let the plate radiate that heat to the spacecraft skins on the inside. This is a simple system that might cost some weight, but it is KISS, and should work just fine. As noted previously, some modules have been designed with an internal heat sink plate that would then attach to this larger plate mounted on the spaceframe. More work will need to be done in this area, now that we understand the principle and the spaceframe geometry.

Launch Design

While as of this writing not much can be said for a launch opportunity, the design preparations for a launch have been proceeding. The spaceframe design incorporates a launch-thrust plate on the bottom (-Z side) that transfers the launch loading into all four core panels making up the central column box of the core structure.

This launch plate incorporates provisions for bolting on an Ariane ASAP5 *Microsatellite* separation attachment. In addition to this mounting, provisions are being made to be able to mount a standard 9-inch Marmon Clamp Band separation mechanism, an old design taken from the Delta program, and often used on the UoSat satellites.

If these launch provisions are not enough, we are also designing an AMSAT separation somewhat based on the design used for our Microsat program in 1990, and one that is traceable back to earlier OSCARS and Jan King's 1972 design. (Talk about antiquity!) This design uses four precision conical locator pins, on the bottom of the spaceframe. These have respective conical sockets on the launcher side of things. Rather than cutting a bolt, as on a Microsat separation, or opening up a nut, as used on the Phase 3D separation, this design uses a thick Kevlar® cord passing through a tube in the bottom of the spacecraft, and then through a cord-cutter and tensioning mechanism on each side of the mount. The tensioning is just done with a bolt-tightening device. The cord cutters are those used routinely on sport parachute operations (and their reliability has been proven!). We plan to provide a redundant design, even though the cutters have great reliability.

So regardless of the launch opportunity, we hope to have the Eagle design prepared for what ever designs may be imposed on us by a launch authority.

Equipment

To this point, I have only been discussing subjects of my training, in the mechanical and thermal areas. The equipment that we plan to be carried on an Amateur-mission of Eagle is depicted in a block diagram chart that came out of the Denver meeting, Figure 7. Please also remember that this satellite is unlike AO-40, it cannot carry everything (kitchen sinks?) that the whole amateur population would desire, just the important communications equipment. We determined that uplinks would be in the U and L bands, with redundant downlinks principally using S band, but also incorporating a V band downlink for the lower altitudes of operation, where the demands on antenna gain are not so great. For a spacecraft of the (smaller) size of Eagle, there is just not any opportunity to mount V band antennas with the kind of gain (≈10-12dBic) needed for operations at the higher altitudes. We wrestled mightily with this point, concluding that V band operations could be included for the lower altitudes, for some ≈40% of the orbit about the perigee, ±50 MA count.

These transmitter and receiver considerations have taken the AO-40 operating experience into account, and found it to our liking for Eagle. Other equipment factors that we considered and incorporated included such things as the cameras, not for the *pretty picture from space* devotees, but at the urging of our command station participants. These command stations have noted the very solid utility of these cameras for the navigation tasks, such as the confirmation of the pointing angles, the ALON and ALAT, of the satellite. Also included are items of necessity, the IHU and BCR modules, and the navigation Sun and Earth sensors. The AO-40 experience in holding down *alligator* stations by the use of LEILA has been beneficial, and so we plan to include that type of unit, too.

The digital aspects of Eagle operation are yet to be determined. The diagram of Figure 7 still reflects the inclusion of a totally separate L-S digital voice operation, but that function will not be in Eagle, as originally thought. The digital function might be another, but much lower power dissipation, RUDAK, as in AO-40. The AO-40 RUDAK is a power hog and its design would need to be *adjusted* to be able to fly on Eagle.

Antennas

Unfortunately, not too much has been done on the antennas, save for what you see mocked-up in my earlier illustrations. These are, however, real and practical patch antennas that we have had some experience in constructing. The real issue is the trade off between antenna gain, altitude, and off-pointing or *squint*. With the Eagle antennas pointing toward the Earth at apogee, where the ALON = 0° and ALAT = 0°, there will be an increasing squint angle for a ground station as Eagle is on either side of apogee.

Ken Ernandes, N2WWD, has provided some of the answers to this situation. He has provided the chart, Figure 8, a Squint Plot showing squint angle as a function of Eagle MA counts, where MA = 127 is apogee (4). There are three curves plotted, one for the sub-satellite point, and the other two being the leading and trailing horizons. Taking only the nominal sub-satellite point for the moment, you can see that a squint angle of 30° is shown for MA of ≈50 counts before and after perigee. Thus a range of squint angles less than 30° is obtained for about 64% of the middle part of the orbit. I will then note that the path loss, Figure 9, for these same MA counts is more than 3dB less than the maximum path loss. This means that if the antenna -3dB half-power beamwidth (HPBW) is about 60° (±30°, the squint angle), then the signal strength will be essentially constant over this operating range, despite the increasing squint angle. And finally, how do we insure that the HPBW is no more than 60°? That is a function of the antenna gain, and typically, an antenna of 10-12dBic will have a HPBW ≈60°. Please note also that antennas of this modest gain do not *drop dead* at the HPBW point, they roll-off pretty gently, so that this analysis could go further and extend the practical operating range closer to perigee. But the point is made and this is our guidance for the Eagle antenna design.

Plans

We have a technical team meeting planned for Eagle in Orlando, FL, for late September 2002. The product of that meeting cannot be reported in this paper, as it is being composed before hand, but will probably be discussed at the symposium at Fort Worth.

Wrap-up

The mechanical design work done so far has been an interesting education, as we have diverged from our nearly constant fourteen year use of Autodesk's *AutoCAD* design products to go full-fledged into a 3D design environment, using Autodesk's Inventor product. I have found that while *Inventor* is quite demanding of the computer resources used (and that is another other story on its own!), it is a vastly superior way to create a design. Its productivity has been far better than *AutoCAD* ever was and it is very precise. The graphics shown are directly from Inventor screen images. An all-up assembly of Eagle with modules and all of the solar cells shown, constitutes a parts count estimated to be in excess of 5000, including every nut, bolt and rivet.

Notes

1 Proceedings of the AMSAT-NA 18th Space Symposium, 27-29 October 2000.

2 *Keep It Simple Stupid*, a rather crass, but basic guidance tenant used to keep the minds of designers on engineering fundamentals, rather than allow them to be drawn to exotic, but not necessarily proven concepts.

3 *Geo-synchronous Transfer Orbit*, the intermediate orbit used for the ultimate placement of synchronous, 24 hour satellites. Typically these orbits have an apogee of 35,786km, perigee of 200-300km.

4 *MA or mean anomaly*, a fractional unit of time in which the orbital period is divided (in this case) into 256 parts, thus 0 £ MA £ 255 defines an orbital period.■

The IDEFIX Project

Ghislain Ruy, F1HDD/ON1RG, AMSAT-France

Editor's Note : This article was originally presented at the AMSAT-UK 2002 Colloquim.

The IDEFIX project is born from the observation that after separation of the main and secondary satellite payloads, the last stage of the launcher is abandoned. Depending on mission, many launchers remain into orbit. As a result, the idea made its way that spent stages and structures could serve as a support for amateur payloads. From an amateur's point of view, this can be considered as a huge quantity of opportunities. Nevertheless, it was necessary to closely examine what benefit could be taken from an orbiting debris platform.

The most common cases are injection into LEO and GTO. Figure 1 shows some ARIANE's last stages and SYLDA/SPELTRA in orbit, LEO and GTO. This is only a small part of the last stages in orbit and representing all stages would have cluttered the picture. At first sight, it is obvious that the main characteristic to take into account is the lack of attitude control. This leads to the conclusion that thermal behaviour and illumination will be difficult to estimate or control and could reach extreme values. The second point is that the antenna system will have to be designed in order to radiate as an isotropic antenna (the holy grail of any antenna designer) or at least guarantee that enough signal will be available in all attitudes given the integration constraints on the launcher. The third point is that the energy source will have to cope with uncontrolled illumination and sub optimal solar generator layout for the same reasons as for the antenna system. The fourth point is the available place and weight on the launcher.

On the other hand, advantages were analysed as follows :

- No pyrotechnic separation system is needed therefore cutting cost and simplifying mechanical design and payload tests.
- The mechanical design of the modules is simplified.
- No launcher's last stage mission preparation for separation manoeuvres,
- Possibly no electrical links to the launcher are required.
- Given the size of the last stage or SYLDA, the antenna separation could give better isolation.
- Quicker and easier design and integration on the launcher.

Weighting the pro and con led to the conclusion that there were usable applications. That analysis was performed during 2001 and ended in December. We thought the concept was worth proving, the only difficulty was to find a launch opportunity and to define a payload that would fit it.

IDEFIX : Defining The Payload

The launch opportunity came sooner than we expected. The SPOT 5 ARIANE 4 launcher was fitted with the ASAP (Ariane Structure for Auxiliary Payload) and NO secondary passenger on it save 180 kg of ballast. The launch was planned at the end of April or begining of May 2002 placing the spacecraft in a heliosynchronous orbit at the approximately 1030 UTC and an altitude of 800 km.

The ballast had the form of 30mm thick aluminium plates fitted on the ASAP (Figure 2).

The last stage global view is shown as Figure 3.

We soon arrived at the conclusion that this launch almost perfectly suited our requirements except that it was impossible to use solar generators for two reasons:

- The ASAP is located between the external and internal cone, therefore in an

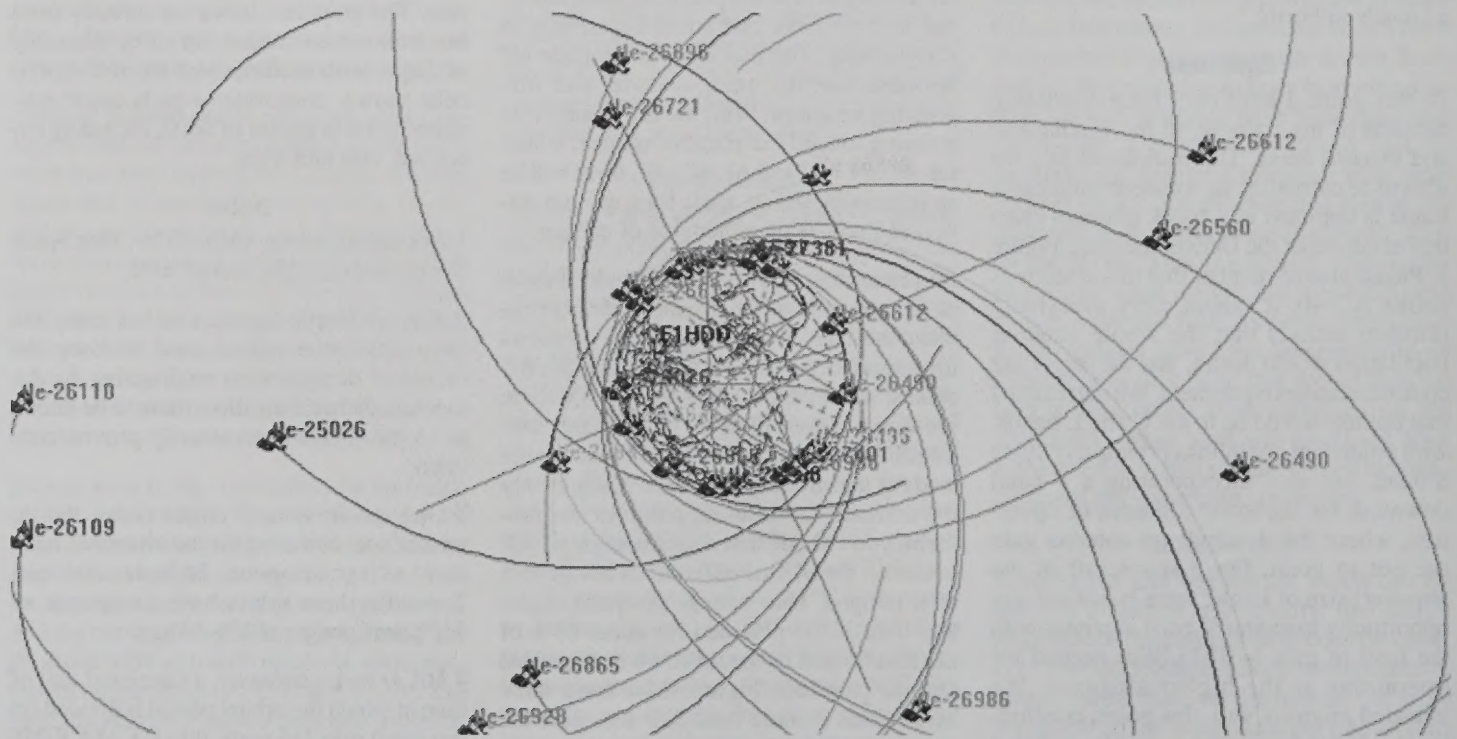


Figure 1. Orbital paths of final Ariane, Sylda, and Speltra stages.

unfavourable disposition regarding illumination and thus there were high risks that the solar generator would be very under illuminated.

• We did not have enough time nor money to build and test it.

The decision was thus made to use high capacity Li batteries as we had used for the Sputniks that were released from Mir.

We also decided to make instrumentation payloads able to give us a quite good idea of what were the temperatures and illumination as well as the behaviour of the third stage once it was left abandoned.

Two totally independent payloads were defined:

• On 145 MHz, fitted with temperature and light sensors and a voice player loaded with pre-recorded messages. The RF power was set to 150 mW into two monopoles 180 degrees apart on the ASAP. This was called the 'fun' payload

• On 435 MHz, fitted with the same sensors but the system was able to store extreme and mean values with a time stamp. There was also the same voice player for identification purpose only. The power was set to 1.2W into two monopoles fitted on top the payload case.

The concept, along with the payload proposal, was presented to ARIANESPACE at the end of January 2002 and these nice people immediately agreed to give us a chance to prove the concept.

Payload Description

Common Parts

The payloads share the same mechanical and thermal requirements. Arianespace requires that payloads, whatever they are, meet the requirements of well-defined sine and random vibration tests. Given the concept, the shock test was dropped. The two payloads are accommodated in standard Weidmuller K61 die cast AlSi alloy cases. In order to get more rigidity, the case is bolted on a 5mm thick Al plate extending 30 mm from either side. To alleviate the need for a lengthy and costly mechanical design of the electronic boards as well as the constraints on the batteries, we used silicon dampers from Hutchison Vibrachoc.

The dampers are bolted on 5mm Al machined corners that are bolted on the ASAP.

The dampers are standard stock but space qualified after backing to outgas. The vibration tests took place at Vibrachoc plant near Paris and proved the effectiveness of the dampers regarding the transferred vibrations on the electronic boards. The final mechanical layout is shown on Figure 4.

Figure 2. Ariane ASAP. (Note person inside static bearing structure ring.)

The energy of the each payload is provided by twelve LSH20 Li batteries from SAFT giving roughly around 600Wh. The batteries are assembled in three rows of four batteries giving 14.6 V no load. This is a suboptimal arrangement since the lower the current drain, the higher the battery capacity. Some restrictions that could not be quickly resoved led to that choice. A better arrangement would have been 2 rows by 6 batteries.

As the payload was to have no electrical connection with the launcher, the best solution to activate them was to use a timer switched on three days before the launch. Arianespace required the timer duration to be 15 days to account for launch delay and reset of the timer, should that be necessary.

The timer is made of redundant cascaded CMOS counters activating MOSFET switches.

The power up of the timer was made through a common connector located beneath a removable panel in the equipment bay of the launcher with an easy access. That proved to be an excellent solution.

The unknown was the thermal problem. In the case where the top of the third stage would not see the sun, it would be exposed to 3°K. Thus at extremely low temperatures, on the other side, should the payloads be exposed to the sun, there would be no cold

Figure 3. Final Ariane stage.

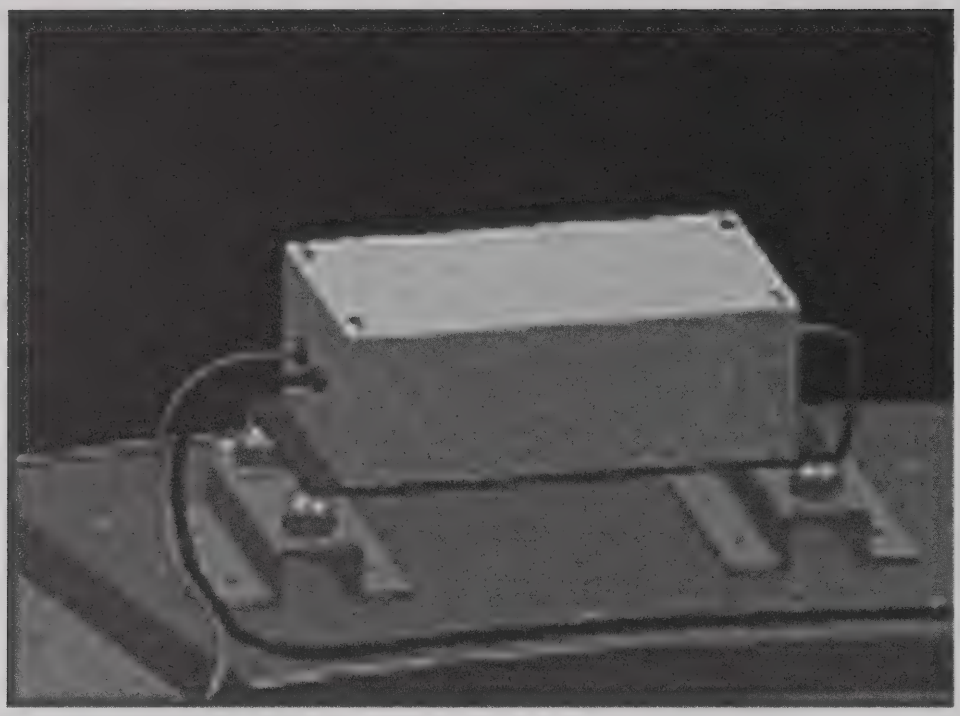


Figure 4. Final mechanical layout.

source and the temperature would rise to quite high levels (add the disposition of the ASAP!). Given the fact that the payloads were to be left switched off for at least ten days, this shows the size of the problem.

We decided that it was better to be hot than cold regarding battery capacity. However, too hot was not a better option.

The solution retained was to thermally isolate the electronic boards and batteries inside the case. The internal sides of the case were left rough while the external sides were mirror polished. This proved to be a quite good choice.

The internal layout of the payloads is shown as Figures 5 and 6. The PCB and two batteries are located on a H like structure 'floating' in the case, while the 10 others batteries are fitted on the bottom of the case with an epoxy isolator. The battery case is fitted with 3 thermal sensor (LM335Z), one is located in the hole in the lower left part of Figure 7, the two others being inserted in the battery rows.

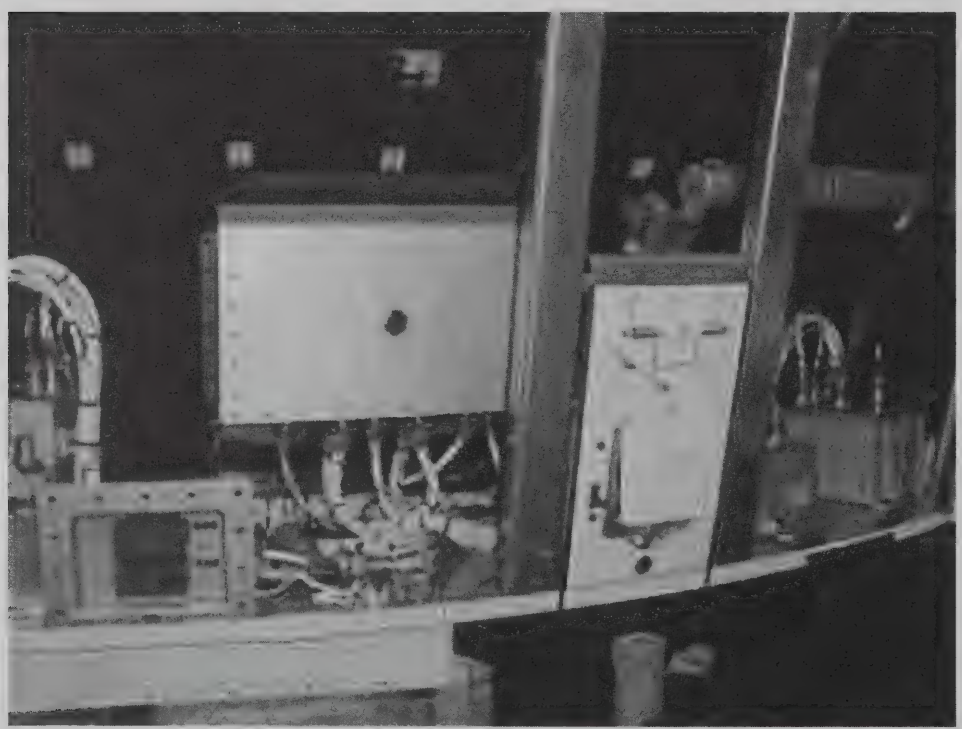


Figure 5. Internal layout of payload.

Each payload has two light sensors that have a cosine response to incident light and are basically made of a BPW21 photodiode wired in photocell mode. The diode is located beneath a PTFE window to give the desired response. A temperature sensor is glued near one of the diodes.

The RF output of the TX feeds the antennae trough a Wilkinson divider.

The telemetry channel is designed to cope with the expected signals i.e. very short subframes with a sync block assembled in frames (and superframes for CU2). The duration of a frame was set to 3 seconds with 0.7-second subframes. It was expected that rapid polarisation changes could occur mainly due to diffraction effects from the edges of the external rim of the third stage. It proved to be a correct assumption.

Payload 1 (CU1)

That payload was meant to be the 'fun' payload. The payload performs the following functions :

- Playback of 6 seconds (mean) pre recorded voice messages
- Measure of 8 analog channels.

The channels are:

- Battery voltage
- Battery temperature (2)
- Case temperature
- Light sensor (2)
- Light sensor temperature
- TX temperature

The transmission scheme is computed to give a reasonable lifetime with short intervals. The sequence is: 6 seconds voice, 13 seconds silence, 3 seconds telemetry, 13 seconds silence. The frequency was set to 145.840 MHz and the power set to 160 mW according to the link budget and expected masking effects. The antenna system is made of two monopoles diametrically opposed on the ASAP.

The payload is made of 4 parts:

- Timer/5V switching power supply

• Microprocessor board with ROM and 8 channels 12 bits ADC

• Piggyback with the voice recorder and adaptation nets for the ADC

• TX board with its own 7.5V and 5 V switching PS.

• The expected lifetime was between 22 and 40 days.

Payload 2 (CU2)

That payload was called the *instrumentation payload*. The payload performs the following functions:

• Measure of 16 analog channels

• Computing minimum, maximum, and mean values of 3 channels with time stamp.

• Play back of prerecorded voice messages.

• The channels are the same as for CU1 plus 5V, 7.5V, recorder temp, CU current, RF output.

• The telemetry superframe is comprised of five 3-second frames transmitted 20 seconds apart followed by a 6-second voice message.

• The frequency is set to 435.870 MHz and the power set to 1.2 W, thus placing a high demand on the batteries.

• Two monopoles are mounted on top of the case at an angle of 90°.

• The payload is made of four parts:

• Timer/5V switching power supply

• Microprocessor board with RAM, ROM and 8 channels 12 bits ADC

• Piggyback with the voice recorder and additional 8 channels ADC with adaptation nets for the ADC.

• TX board with its own 7.5V and 5 V switching PS.

• The expected lifetime was between 12 and 15 days.

Integration.

Figure 8 shows the final integration on the ASAP.

Results

Signals: The signals were strong and the power could have been reduced by 6dB on 435MHz. CU1 was heard with a simple dipole in the best cases and a 4-element handheld Yagi otherwise. CU2 was heard with a 7-element Yagis and a 19 -element Yagi proved to be comfortable in all cases. The attitude changes of the third stage were clearly seen in the signal strength but never prevented reception. The diffraction effects on the external rim played a major role in that. The telemetry frames were consistently received.

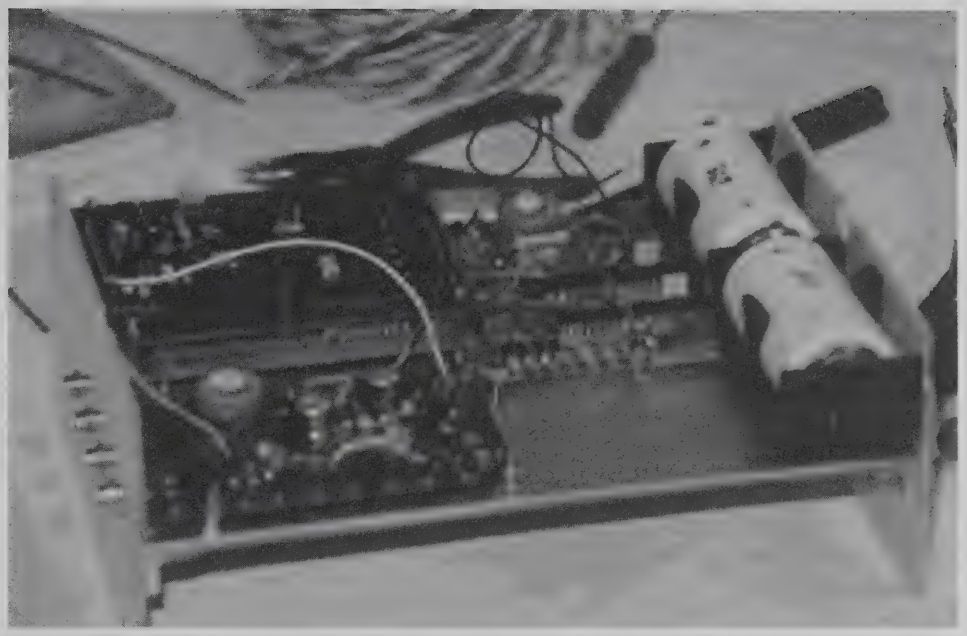


Figure 6. Internal layout of payload.

Lifetime: Both CUs switched on 07 May 2002.

CU1 stopped transmitting after battery exhaustion on 20 May 2002 and worked fully as expected.

CU2 stopped transmitting on 08 June 2002. The ADC telemetry channel was crippled with a thermal problem that was analysed as a PCB track crack showing up above 22°C after some days. The lifetime of CU2 is on the lower boundry of computed values. This is attributed to the fact that the third stage's attitude was not optimum during the first days of life leading to low temperatures hence reduced battery capacity. CU2 lifetime was halfway between min and max to positive evolution of attitude giving higher temperatures.

Figure 7. Battery case.

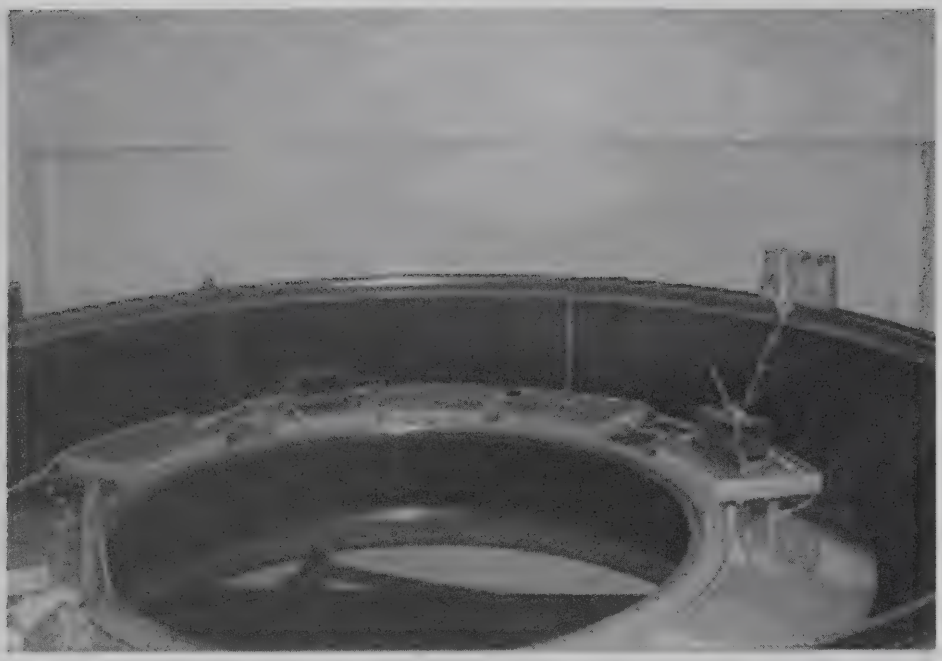


Figure 8. IDEFIX payload on final stage.

Telemetry: The most interesting thing to be noted is that the temperature is loosely related to the orbital period, the variation being less than 4 °C as shown by CU2 min/max measurements. The attitude of the third stage is the prime effect of the temperature variation. The third stage showed two combined movements:

A spin with a period of 1- 2 minutes, slowly decreasing,

A tumble of greater period.

Both combined to give the following temperature inside the payloads (CU1 results):

Spin: (from light sensors) The masking effects of the internal cone and external rim are seen. The temperature excursion ranges from –22°C to +40°C. The later value comes from the interpolation of the curve and the estimates given by a special recorded test message whose frequency was temperature dependent. Clearly seen is the slowdown in tumbling which is attributed to magnetic damping.

The temperature range is far less than expected and the main cause is attributed to the thermal inertia of the upper part of the third stage.

Conclusions

• The concept has proven to be valid. The design and integration periods are largely reduced as well as the cost. Receiving the signals has been possible in all cases despite uncontrolled attitude and unfavourable antenna system.

• A minimal team worked only for three months.

• Optical tracking has been possible during clear nights as the third stage is a big and bright structure.

• We are now beginning studies for integration on AR5's APS or SYLDA structure to take advantage of their more favourable disposition. And particularly, solar generators should be easy and worth to use. Our goal is to study a GTO payload capitalizing on the excellent results of IDEFIX (BreizhSat 47 and BreizhSat 48).

• And finally, IDEFIX is the biggest, heaviest and brightest amateur satellite ever launched !☺

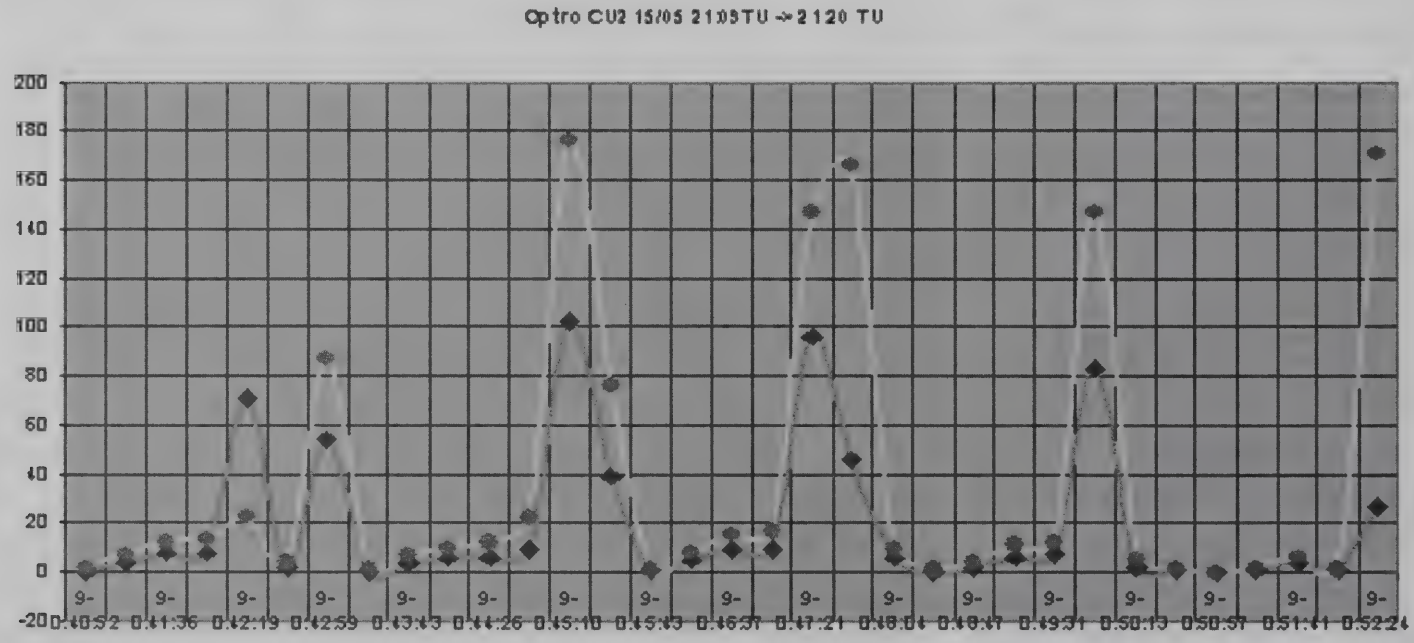


Figure 9. CU2 telemetry.

Field Day 2002 Results

Bruce Paige, KK5DO, Vice President, User Services

This year a total of 38 logs were submitted. Of these logs, 29 were Emergency Power class and 9 in the Commercial Power class. Submissions came from all over the United States and Canada with several foreign entries from Mexico (XE1MEX and XE2AT), Slovenia (S57NML), and Belgium (ON5LL).

Here is a break down of the 1905 total reported QSO's.

Satellite	CW	SSB	FM
FO-20	6	221	
FO-29	6	130	
RS-13	2	37	
AO-40	265	1132	
UO-14			18
SO-41			14
ISS			11
NO-44			4
UO-22			59

Sitting on top of the pile for Emergency Power class is K4BFT with 244 points. Operating this winning station were N8DEU, N5DF, KX4Y, N5AYD, KE4ROL, N4LO, K4TFJ, K4JCH, KE4AHR, KB3AXR, W4RK, KD4TFN, N4TXI, and KG4CP. Following behind them in second place is N4TP with 191 points. KG4ITU and AA4MD did all the work here. K5OE was used by K5OE, W5ACM, KK5DO, AG5RS, N5EM, WA5TWT, WA5WOD, K5ENG, WB5TKI, and Scott Kendall (ex WA5LHM) with 172 points taking third place.

For Emergency Power at Home class, Randy, N7SFI takes first place.

There were many good field day stories and a lot of pictures. I would like to share some of them with you and apologize to those whose pictures could not be printed, simply not enough room.

The travel trailer in Figure 1 belongs to the N4TP station. These guys do a great job at hamfests and own a place at the top of the Emergency Power class.

In Figure 2 from the ON5LL/P field day site are (left to right) PA5RWE, ON5GS, ON6MP, PE1RAH, PE6YES, and PE1NLZ. It looks like they were having a bit more fun than they should have.

KQ6EA and his son in Figure 3 were having a good time at field day this year. They were operating portable for the K6AA station. His comments for field day... "Just wait until next year."

Of course, there is always a problem with something and at the K5OE field day (Figure 4), there was one set of rotors using the control box just would not point correctly. So, how do you figure out where the antenna is pointing? You attach glow sticks (red and blue) to each of the antennas and you can see them just fine at night.

Our final picture (Figure 5) belongs to Bill, W1PA operating Sunday morning after a sleepless night. There were some other really great pictures. W9RCA sent along his mobile AO-40 station and from Wichita we had some pictures with W0OQC and N0ZHE. From Ft. Worth, we got some cool pictures of Keith, W5IU.

Randy, N7SFI, said that this year he refused to use any power amps and when he powered up his 9600 baud TNC, it failed. He had mountain tops to the south and west of him and went to bed about the time the AO-40 beacon was heard thinking his barefoot radio would not be heard.

Dino, VE7XDT, made this his first field day having only worked the satellites for two months. He really enjoyed it. He was operat

Figure 1. N4TP Field Day Station.

ing for his club, VE7SUN.

Jack, K2BMI/2 says "What a Blast" after operating AO-40 exclusively with his antennas on the back of his Geo Tracker. Stephan, KS1G, said "that the non-satellite ops were quite impressed with what we could do and hear with modest equipment."

Of course, we wouldn't have field day unless we had the diehard operators. Allen, N5AFV, got out of the hospital several days before field day and he was operating from his house with an IV dripping antibiotics into his arm. If you have ever been to a field day and operated satellites, this comment from Jim, KQ6EA, says it all. "ARRRRGH!! First SAT operation for my club. What worked at home didn't work at the site. Lost cables, missing parts, four trips back home and my AO-40 dish blew down Saturday afternoon. We could hear ourselves on the downlink, but couldn't make any contacts."

If you ask anyone that participated this year about next year and if they are gong to do field day again, the overwhelming response is "Just wait until next year."

I would like to thank everyone that participated this year and submitted a log. A few people made extra contacts on the FM satellites but our rules limiting contacts on them to one helped those that were participating in the ARRL field day to get their one 100 point satellite QSO.

Here are the rankings with their point totals.■

AMSAT Field Day Results - 2002

Rank	Group	Class	Score
1	K4BFT 5A		**244**
2	N4TP	2A	**191**
3	K5OE	3A	**172**
4	K5XB	1A	**169**
5	K2BMI/2	1B	**154**
6	N9IP	2A	**150**
7	VE7SUN	7A	**146**
8	NX2Q 2A		**139**
9	W2LV	3A	**109**
10	ON5LL/P	2DX	**103**
11	XE2AT 1DX		**81**
12	K6HAI 4A		**76**
13	K6PUD 22A		**76**
14	W9RCA	1A	**76**
15	W1PA	3A	**75**
16	WA4MM	3A	**63**
17	VE3KRG	3A	**60**
18	WW5X 1A		**57**
19	KC0AHN	4A	**54**
20	W6ZQ 1D		**50**
21	W5IU	3A	**49**
22	W4MVB	1D	**40**
23	K2BAR 2A		**36**
24	W4BOC 4A		**36**
25	K6YK 1D		**29**
26	KB6A	1D	**29**
27	VE2DWE	1D	**29**
28	XE1MEX	1DX	**29**
29	N7SFI 1E		**15**
30	W5KS 1A		**12**
31	K4RS	2A	**9**
32	W9INL 2A		**9**
33	K6YA	2A	**7**
34	S57NML	1DX	**6**
35	W4NLX 6A		**4**
36	N5AFV 1D		**2**
37	W5BTS 1D		**2**
38	K6AA	6A	**1**

Figure 2. ON5LP/P Field Day Site.

Figure 3. KQ6EA and Son operating portable for the K6AA Field Day Station.

Figure 4. Rotators and Antennas from K5OE Field Day Station

Figure 5. W1PA Field Day Station.

Report of the AMSAT Board of Director's Meeting
Held April 20 and 21, 2002 in the Washington DC Area

Members of the Board of Directors (Board) in attendance were:

Barry Baines WD4ASW
Keith Baker KB1SF
Tom Clark W3IWI
Dick Daniels W4PUJ
Robin Haighton VE3FRH
Bruce Paige KK5DO
Bill Tynan W3XO (Chairman)
Rick Hambly W2GPS - First Alternate

The following Board members also hold the offices indicated;

Barry Baines WD4ASW - VP, Field Operations
Keith Baker KB1SF - Immediate Past President
Tom Clark W3IWI - President Emeritus
Robin Haighton VE3FRH - President & Canadian Liaison
Bruce Paige KK5DO – VP User Services

Others participating or observing at various times included:

Art Feller W4ART - Treasurer
Mark Kanawati, N4TPY - SpaceQuest Ltd. and AMSAT Member
Perry Klein, W3PK VP, Government Liaison
Dino Lorenzini KC4YMG, SpaceQuest Ltd. and AMSAT Member
Linda Jacobson - SpaceQuest Ltd.
Lou McFadin W5DID - Orlando Lab Manager
Martha Saragovitz - Corporate Secretary
Ray Soifer W2RS - VP, International Affairs
Stan Wood WA4NFY - VP, Engineering

The meeting began at 9:30 AM Saturday, 20 April 2002 with a tour of the SpaceQuest facilities in Fairfax, Virginia where the attendees were shown the intended design for the AMSAT Echo satellite, including a demonstration of the *Flatsat,* a board on which all of the spacecraft's components are laid out and interconnected to be certain of their proper functioning together.

Following the SpaceQuest tour, the meeting was convened by Chairman Tynan at the ARRL Washington area offices.

I. The AMSAT OSCAR-E (Echo) Project

Haighton announced that concern about the cost of continued funding for the new Eagle spacecraft was the principal reason for calling this meeting. A second reason was for the Board members and others to hear from, and talk with, SpaceQuest personnel with which AMSAT has contracted to construct the AMSAT Echo spacecraft (AO-E). Echo is based on an updated Microsat design and is to serve as an appropriate project to fulfill the desire of AMSAT-NA to build and launch a satellite that will fill a need within the amateur community; and, at the same time, be in accord with the organization's capability both technically and fiscally. It was noted that SpaceQuest has recently constructed the SaudiSats, now designated SO-41 and SO-42.

A detailed description of AO-E and the potential payloads it may include were outlined. [Note: A description of the spacecraft and its possible payloads appeared in the article by Rick Hambly published in the May/June 2002 issue of *The AMSAT Journal.*]

Mark Kanawati provided a technical review of the proposed spacecraft including the antennas, receivers, transmitters, technical constraints, protection circuits and the possible modes. It was noted that the requirements for antennas for other payloads will have an impact on the installation of the solar panels. Tynan suggested making it an action item for Wood to evaluate possible use, for other applications, of the 18" AMRAD-designed antenna to be used for the broadband receiver. Wood said he would need the flight antennas to do this, so the item was referred to AMRAD.

The choice of secondary payloads is pending the antenna findings. Daniels recommended directing most of the decision-making to the management crew.

Another item discussed was the CPU board that will have 15 MB of static RAM in addition to the 1 MB of EDAC memory. Lyle Johnson is working on this. It was affirmed that there will be two UHF transmitters, typically running 7-8 watts and capable of operating at the same time. They will feed circularly polarized antennas that have already been proven in space.

Soifer asked if the transmitters are to be operated full time and at what RF power output? Kanawati estimated it would be 1 watt per transmitter although he noted that at this low RF output, not much power is being saved as the transmitters have about 10% efficiency vs. 25% at the 7 watt out level. He said that ordinarily he would not recommend running both transmitters 24 hours per day, 7 days per week and stressed the limited power available. This may mean that operation at night must be different from that during the day. He noted that the spacecraft will contain 6 batteries of 4.5 amp hr capacity, each to provide approximately 34 Watt-hrs. They will be Sanyo NiCds as used on AO-27 and the SaudiSats. Power generation is limited to about 25 watts maximum from the planned 19 to 19.5 percent efficiency solar panels. He indicated that it may be possible to obtain 27 percent efficient solar cells, but considered this option unlikely. He stated that SpaceQuest can fabricate the panels.

Clark noted that the largest single expense will be for solar cells and that it is not likely they can be obtained through donation as sometimes in the past? He added that there are opportunities here to learn how well our volunteers can assemble solar panels so that we don't have to depend on outside sources and we can develop an in-house capability as we have done with batteries. Tynan asked if SpaceQuest would be willing to train AMSAT volunteers, to which they answered in the affirmative. Klein called attention to the recent survey of members that has identified prospective candidates for this type of activity. Kanawati then provided lists of the components to be supplied by SpaceQuest. With regard to telemetry, the boards have only a 3-wire bus and the decoding programs are similar to those used for AO-40.

Kanawati noted that all experiments must be designed to operate from an 8-volt bus,

Potential operating schedules and schemes were discussed including having a transmitter turned on only when a properly encoded signal is being received.

Haighton noted that the planned receiver has a 4-channel capability plus another for command and control. He asked about the channels available for the two transmitters? The reply was that there is one channel per transmitter. Haighton then asked about provisions for control should the control channel fail and the reply was that the 4 other channels could be used and possibly even the multiband receiver. Clark opined that a more likely failure mode would be the computer. More discussion about control backup followed. Clark stated that it would be prudent to address how to allocate our resources in the best way and to start considering how to use this satellite. Haighton agreed and added that knowing and publicizing what can

be done with it will increase interest in the project.

Kanawati continued with a description of the unique mechanism to be used to release the satellite from the launch vehicle. Concluding, he said that help may be needed in design and construction of various pieces of RF hardware, as well as in the aforementioned solar panel fabrication.

Wood was granted the floor to describe his work to provide a successful 70 cm transmit antenna design for microsats identified as "M." It consists of 4 quarter wave whips angled to about 45 degree giving an circularly polarized, omnidirectional pattern. He said that this antenna will be used for Echo in addition to an 18" whip for VHF. He added antennas are needed for the L and S bands as well as multiband HF and LF. He noted that some antennas could be used simultaneously on more than a single band at the lower frequencies, but this doesn't work well at the higher bands.

Clark expressed concern that if the LF experiment is to work, the antenna placement should be reconsidered because putting the HF and VLF receive antenna in the middle of that much transmitted power may cause problems. He suggested achieving as much physical separation as possible. His suggestion was to fly one 18" whip and add a multicoupler so it can serve as an antenna for both the HF and LF receivers. Wood pointed out that the AMRAD (LF) receiver requires a low capacitance (10 pF) so the problem is how to siphon off signal to the other, e.g., L, bands. Wood questioned the need for a separate 2 m antenna and noted that the location of the S band antenna is dependent on space available. There is likely insufficient space to mount a patch antenna. Clark suggested using a stacked L/S band patch antenna with a single aperture. Another possibility suggested would be to put solar cells on top of a patch. However, Wood contended that a patch antenna is not needed, suggesting instead, a dual band L/S band monopole.

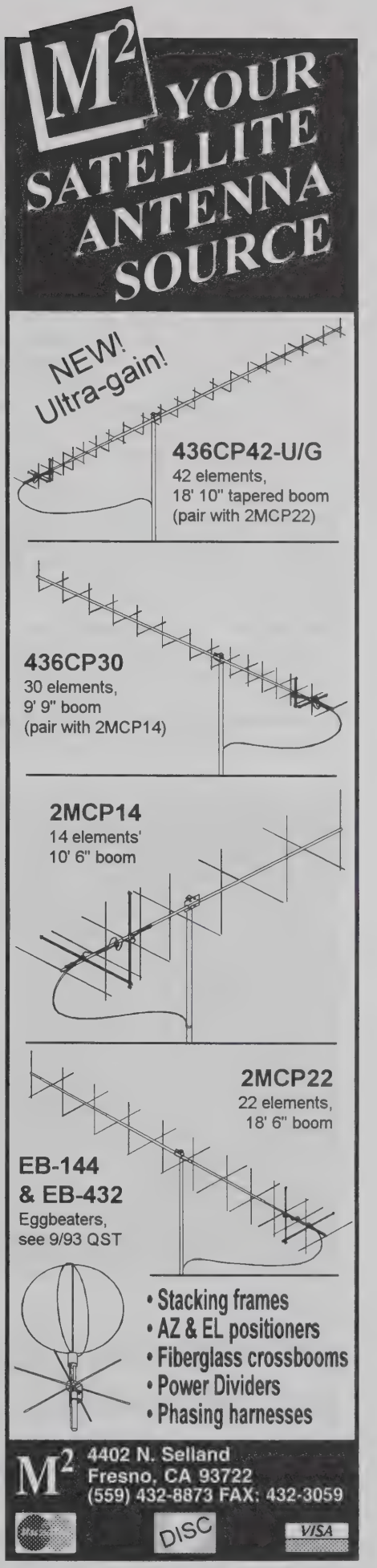
Haighton emphasized the importance of informing the membership of the various design problems being dealt with.

A more in-depth review of secondary payloads followed. Hambly reported that a meeting had been held to review and eliminate some of the candidates. It resulted in 11 optional projects that are still under consideration, although some are not payloads in that they require no on-board physical devices to implement them, merely operational capability such as linking bands or modes. The candidates were judged on their value to ham radio, advancement of technology, risk and other practical factors. He noted that one very much in contention is one is Karn's ADCARS (Advanced Data Communication for the Amateur Service) proposal, for which a LEO spacecraft is ideally suited. It remains among the favorites because it supports advancement in the state of the art.

He outlined the project as follows: the idea is to take a section of spectrum, and rather than use it in the traditional frequency division multiplexing manner we are accustomed to where each channel in that section of spectrum is used for one QSO, to take the same large chunk of spectrum and treat it as a single channel to be used all at once by many users transmitting high speed digital signals, each of then being assigned a time slot in the overall digital stream. Thus, each user gets a piece of time rather than a group of frequencies. He emphasized that there are various advantages to this approach including eliminating the need for linear transponders and their many pitfalls. However, he conceded, despite this simple sounding explanation, there is significant risk attendant with this approach. Technological advances are needed to support it, both on the spacecraft and in ground (user) station equipment. One of the premises of the project is that patented, or proprietary technology, is not to be used. Everything is to be open source. He noted that one of the features of such systems is that, Doppler shift associated with S-Band operation, is not an issue due to the wideband (0.5 MHz) nature of the signals. Summing up, he emphasized there is much development work to be done, and he pleaded for additional volunteers to become involved with this new and exciting project.

Soifer asked what has changed since last year when Karn said that one thing he wanted was to have all the digital components of the system for the ground terminals developed first? He recalled that Karn had, at that time, emphasized that his vision was for a system, not merely a satellite; and in order for it to succeed AMSAT would have to change its *modus operandi* and become actively engaged in the development of suitable ground station equipment.

Hambly's answer was the emergence of Echo and its compressed time scale has made it necessary to tackle the space segment equipment first. He further expressed the concern that people might not be interested in acquiring new ground equipment for which no satellite exists, and expressed the opinion that the project is too important to allow that to happen.

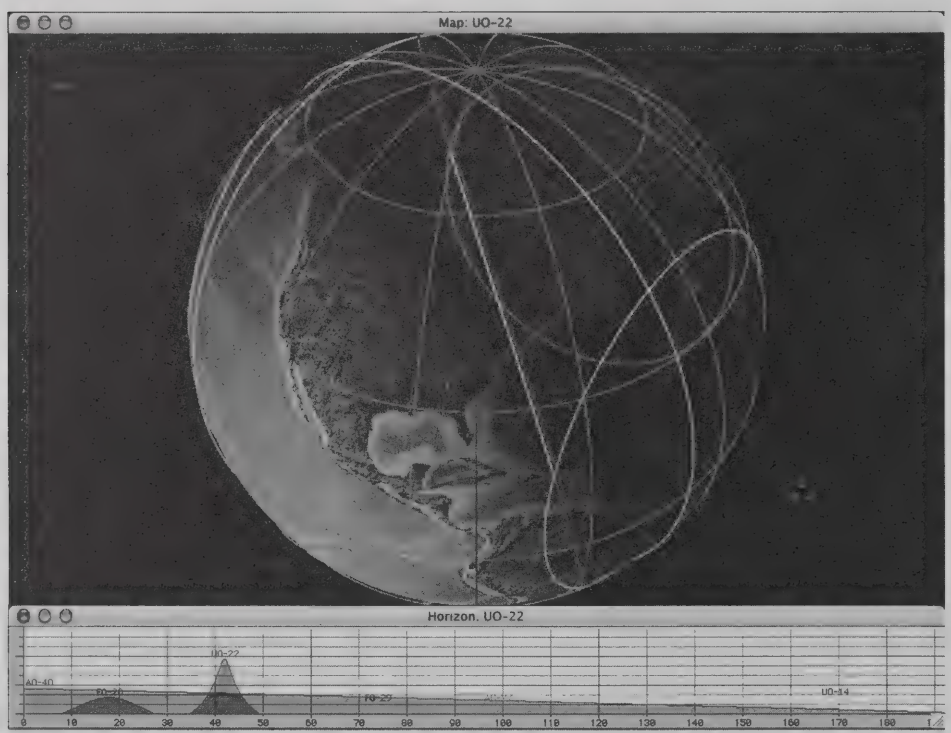


He also mentioned the option of including an on-board processor, which could be optional or even switchable in/out. He provided details how having this processor can eliminate noise in the downlink signal plus providing an opportunity to insert link data such as telemetry or anything else going on in the other payloads. If the processor should fail to function properly, it could be switched out and the receiver hard-wired to the transmitter. The complexities of handling the data and avoiding some of the problems encountered with bent pipe transponders were then mentioned by Clark who characterized the processor described by Hambly as a "smart demodulator/demodulator box that pulls off enough of the bits to do all the error correction before it sends it down clean data.

The question of software requirements was brought up. Hambly emphasized that Karn remains adamant that this project be open source for both ground terminal hardware and software.

Haighton then asked if we could come up with a ground station design in time for a late 2003 launch? Hambly replied that it's likely that we might have some preliminary ground stations available in this time frame, if we can find the right volunteers to work on the project. Haighton then asked what was the optimistic estimate of the cost to the user for such ground station equipment? Clark guessed that it would be $100 to $200 although in reality it might be twice that. Tynan opined that $300 would be about the most hams would want to spend on such equipment. Clark reminded everyone that Karn's goal is to have a system an apartment dweller can use. Hambly confirmed that this remains the goal. He stated that among the most expensive parts of the typical ham rig are the front panel assembly, the interfaces and the wiring but that all of that can be eliminated by using the almost universally available computer. So it becomes almost like a software-defined radio. A further step may be to develop a ground station for mobile use that doesn't require a computer.

Tynan asked about the satellite's launch date. Lorenzini replied that to make a 2002 launch, the launch contract would have to be signed soon and it's really past the time the launch should have been booked and a deposit put down. He added that the only reason we could do it this late is that the launch agency understands the satellite's design and characteristics and they already have the adapter plate.



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The Board agreed, as did Lorenzini, that a 2003 launch would be the better option. Haighton offered a motion to accept a baseline of a late 2003 launch, to define the satellite, to go forward with the contract with SpaceQuest Ltd. to build the satellite and to define what funds will be provided during the building of the satellite. Baker seconded and the motion passed with no votes opposing.

Tynan noted that the original late 2002 launch date would have precluded inclusion of even a simple bent-pipe L/S wideband transponder. Now, with the information that a late 2003 launch is more likely, he opined that we should re-assess this option.

General agreement with this conclusion was expressed.

Hambly completed his presentation with a summary of the candidate payloads, not in any order of preference:

1) ADCARS, described above.

2) The AMRAD proposal for an L-Band to S-Band television transponder.

This was an unlikely choice but it's still on the list because we would like AMRAD to work with us on the other L/S project.

3) The proposal to fly a GPS receiver

This has been impeded because the best receiver to use is not available now. But Clark will revisit the issue in the light of a late 2003 launch. There are also weight, power and antenna problems associated with GPS hardware.

4) Active Magnetic Attitude Control (AMAC) system to improve stabilization of the spacecraft.

This is presently moving ahead.

5) Audio Recorder Experiment

This is critical to ADCARS, not because we're going to record any audio, but because the "smart" processor to derive the full benefit of the experiment is imbedded in this system. Clark explained that it includes a high-speed analog to digital converter. A meeting is needed to further define this and what support and development it requires. Haighton added that software is being written for this by Cliff Hall in Australia. The need for additional team members was noted.

6) A low frequency receiver proposed by AMRAD uses the LF capability of the multiband receiver to study propagation from above the ionosphere.

7) APRS digipeater.

Hambly observed that this is limited to 9600 baud only, VHF up and UHF down. With those parameters it will be compatible with Kenwood APRS transceivers. An uplink frequency has been chosen. Clark added that this, like PSK-31 capability is really an operational capability, not a hardware issue. He said the question of what the best frequency choices are is the type of thing to get the operations people thinking about it and then turned over to them, because this is a management not a technical issue. He questioned the use of the term "payload" here and said he would like to hear them referred to in a way that distinguishes them from real payloads.

8) PSK-31 capability with a 10 m receiver and UHF transmitter.

It was noted that it too is not actually a payload because there's nothing to do as long as one of the antennas can be made to work. Wood said there is one technical problem here but it can be solved. Hambly noted that the multiband receiver was originally an optional payload and its choice of antenna is still an option as discussed earlier. Tynan asked for a sense-of-the-board decision that the team should go ahead and try come up with a suitable antenna design to permit 10 meter reception. The Board generally agreed.

9) The Multiband receiver and antenna for LF through L-Band as proposed by SpaceQuest.

This is moving forward.

10) The possibility of implementing a different solar panel array with much higher efficiency than the present guaranteed minimum rating.

The inherent difficulties of cost and availability were acknowledged but it was agreed that if cells of greater than 20% efficiency can be found, a dramatic improvement in operational capability would result. Daniels asked if baselining a late 2003 launch would affect SpaceQuest's proposal for constructing the arrays? Lorenzini replied that it is appropriate to buy all the cells at the same time. Hambly noted that, if SpaceQuest wants to use the higher efficiency cells for their own satellite, it would be cost effective to add ours to their order. Tynan agreed that this is in the hands of SpaceQuest, to which Hambly agreed and added this item will be kept on the list.

11) Robust Telemetry Link.

There is a proposal that this, and all subsequent AMSAT satellites, use this. This would include command and control and everything that has to do with downlink data on a low speed data channel. This channel would be encoded in such a way as to avoid what happened to AO-40 when unexpected events arose when the channel was almost useless, though with the simplest coding techniques it could have been error free. Hambly stated that we are preparing to do that on this satellite and added that discussions by the Project Committee, and Karn, are underway to determine how best to accomplish this improvement. He emphasized that this is separate from ADCARS experiment. Hambly also noted the work has been done already, and published as open source. Baines asked how many payloads are there room for. The answer was "three". It was again pointed out that not all the above are physical payloads.

Haighton asked for a consensus that thanks be expressed to SpaceQuest and ARRL for their hosting this morning's meeting. This was done and this portion of the Board meeting was adjourned to be reconvened in the afternoon at the AMSAT office in Silver Spring, Maryland.

The meeting reconvened at the AMSAT business office in Silver Spring, Maryland at 2:48 PM. Those present included:

Barry Baines
Keith Baker
Tom Clark
Dick Daniels
Art Feller
Robin Haighton
Rick Hambly
Bruce Paige
Martha Saragovitz
Ray Soifer
Bill Tynan
Stan Wood.

II. Eagle Satellite Progress and Outlook

Stan Wood announced that the principal activity in the Eagle project over the past few months has involved Lou McFadin, Dick Jansson and him working on the mechanical design. He reported that a reasonable design has now been achieved. It calls for a 600 mm cube with wings for the solar panels and a mass in the 50 kg class. It will use spin stabilization with magnetorquing and simple sensors. So basically, it is an updated AO-13, hopefully with no propulsion system. He noted, however, that it might be necessary to include some propulsion in order to raise

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Wood reported on the software recently purchased for structural design and stated that it allows designing and drawing the spacecraft and does much of the stress analysis.

The options for propulsion have also been examined. Wood stated that, if an Ariane vehicle is used it will have a perigee of about 200 kg. This means that on-board propulsion would be required to raise the perigee. This is because ArianeSpace has gone from a 500 km perigee GTO to a *self-cleaning* 200 km one where the debris will de-orbit relatively soon after launch. It also allows them to carry more mass to the final orbit. Many types of motors have been looked at including one from Atlantic Research that has been found to be very reliable and is available either as components or the complete system. Citing the problems encountered with the AO-40 propulsion system, Wood urged buying an off-the-shelf unit that is already space qualified. Daniels agreed that it would be hard for us to get certification for an AMSAT-built unit, and he added that at the time of purchase we should receive an accompanying certification document. Wood stated the need for us to establish contacts with the manufacturers of propulsion systems in the U.S. to find out what is available and appropriate for our use. Clark suggested contacting Rick Fleeter of AeroAstro. Tynan asked for an action item specifying who should talk to Fleeter. Daniels was chosen to do this and he said it would be worthwhile to also contact Martin Sweeting. Haighton offered to do this. Tynan opined that at this stage we should just be collecting information about the technology available. Further discussion followed with Wood announcing he would look into a microwave propulsion system he has recently heard of.

Wood went on to state that Eagle will not have many transponders unless additional projects are sponsored and he asked Haighton for suggestions as to what these might be. The reply was that it might be Mode B (U/V) as well as L/S.

He reported that not as much work has been done regarding the electronics, but the concept is for a 50-100 RF watt output,

Tynan suggested that various designs being developed for Echo might be applicable to Eagle. Wood stated that the flight computer for Echo is not radiation hardened which would present a major problem for Eagle. Haighton said that Johnson has resumed work on a flight computer and Chris Hill in Australia is reportedly writing some of the code. Tynan noted that Intel is reportedly coming out with a radiation hardened version of the Strongarm processor.

Wood continued his presentation noting that it is felt that the structural design that has evolved should be compatible with most of the potential launchers. There are only a few options available, he noted. He and King have listed the types of launchers that might be available and with which we are familiar. He learned that secondary payloads are rarely carried on Atlas rockets, while an impressive number have been launched on Delta rockets. However, Wood noted that we haven't done anything with U.S. launches since 1978 when a Delta launched OSCAR 8. It was also learned that Microsat-sized payloads could be accommodated on most missions with little trouble, although anything larger will require working out an interface with the launching agency similar to what we had done with ArianeSpace. He said we need to make a proposal where there would be a greater capability to launch secondary payloads based on the fact that we would design and build the particular interface, e.g., an ASAP. The problem with the Delta is the manner which they jettison the faring. It turns out that many of the surface areas of a Delta that might look suitable for a payload are not satisfactory because the jettisoned faring goes flying through that space. Thus there are not a lot of options for launch vehicles. So, he concluded, we are back to looking at Ariane with a cost estimated at $2 million regardless of the spacecraft size. The bottom line is that, at present we don't have a good, economically feasible, launch opportunity in sight for Eagle. Haighton said he had talked to Boeing and they were not interested, but added that after the satellite is completed, we will talk to various launch agencies. He added there is the possible option of the Australian mission, if and when their project gets going. That will probably be not earlier than 2006. He added that a complicating factor is that, if a launch is into an equatorial orbit from the Indian Ocean, provisions may have to be made for flying over southern Malaysia and Indonesia. Another problem may be that the Christmas Island launch area is being set up as a refugee internment site.

It was noted that the Japanese have had one successful launch of an H2 rocket. Tynan asked if the H2 goes to GTO and Haighton said he would find out. He mentioned that another interesting possibility is that the AMSAT group in India is planning its own Amateur Radio satellite and hopes to launch it on an Indian rocket. This, undoubtedly will be low orbit, with later launches possibly going to GTO.

It was emphasized that the issues of export licenses and technology transfer would have to be handled with any foreign launch. Haighton said that the three launch possi-

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bilities must be investigated and he will do what he can. Daniels offered to investigate additional possibilities of which he has become aware.

Another consideration mentioned involves the proposed FCC rule regarding mitigation of orbital debris. It was noted that this may play a part in any final design for Eagle. Tynan stated that we will have to wait for the FCC rules before determining what effect they may have on any of our satellite designs: but that we expect to participate in the comments on the Notice once it is available.

Haighton summarized the problem of finding launch opportunities for Eagle, concluding it will take at least a year to resolve this. Wood added the launch will be 3-4 years later.

Wood suggested the possibility of going on an Ariane 5 ASAP launch.

Haighton stated we have further to go with planning for Eagle and he needs the financial information to make the proper decisions.

Baines asked if any of the Projects Committee members are involved with Eagle? Haighton replied Jansson, Wood and McFadin.

Those present said they would like to receive more information about the project's developments.

Saragovitz presented the Financial Statement and information about the fiscal status of the organization through the end of 2001. She stated the first major concern is the decline in income from membership renewals. These have fallen 20-30% from previous years. She opined that the primary reason for this is the failure of AO-40 to do what had been promised and secondarily the decline in the U.S. economy along with the impact of the September 11 attack. Donations have markedly fallen off since then. Baker added that the aging nature of the ham population could also be included in this analysis. Clark added that today that the hobby is suffering from malaise because the enthusiasm is no longer there. Soifer countered, saying that ARRL membership is reportedly up 1%. Clark opined that the Dayton Hamvention is a good place to employ the approach of *shaming* non-supporting satellite users into becoming members and suggested that Baines take this as an action item. Saragovitz said that it wasn't clear to many hams why they should become AMSAT members and agreed that we should employ tactics similar to those used by Public Broadcasting stations to explain to users why they should provide support. Haighton agreed and suggested that those stopping at the Dayton AMSAT booth be asked if they are now members. Haighton's opinion was that we need to immediately start talking up these new satellites. Saragovitz added that our public relations efforts have so far been ineffective. People don't know what we are doing and our announcements have been vague.

Saragovitz mentioned that we tried advertising in *CQ* magazine, which proved ineffective for the amount of money spent. Since then, Steve Ford at ARRL has designed a professional looking ad for *QST* that will appear at no cost to us when excess space is available. Martha then received a vote of thanks for arranging this. Tynan said the immediate problem is what can we do with the Eagle project as a result of this financial report. Later we can brainstorm on how to fix the situation. Saragovitz reported that, as of March 2002, there were 3,723 domestic members and 676 in other countries. This includes Life Members who receive *The AMSAT Journal*. She concluded that the big problem now is how to enroll new members and keep the ones we have. This was agreed, and it was noted that it is easy to offer books for cash donations but difficult to enroll new members at hamfests.

Haighton noted that he had asked Saragovitz to find the rates for advertising in *Space News* and they were found to be more than we can afford. He then noticed an article in that publication dealing with the VUSat being built by AMSAT-India that gave them good publicity. Tynan agreed that an article about AMSAT-NA would be better than an advertisement. Daniels noted that although a senior editor of *Space News* had visited with the AMSAT group at the premier of the new IMAX film about the ISS, we have repeatedly been unsuccessful in getting an article about Amateur Radio or AMSAT-NA into that publication. Tynan said he too had found it difficult to get material accepted for publication in the non-amateur press.

Tynan offered the opinion that satellite users should be members and that we should make that clear in everything we write and say. He admitted, however, that there is no way to enforce this. The question of offering incentives was discussed, with Saragovitz stating that including a free copy of the latest InstantTrack software with the Kansas City Tracker (KCT) did not increase the number of orders. She added that, in spite of the concern expressed at an earlier Board meeting, we have distributed the backlog of KCTs and the supplier will provide no more now that the final shipment of 25 has been received.

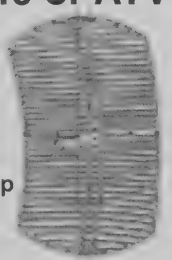
III. Review of AMSAT Financial Position in the Light of Echo Commitments, Fund Raising Prospects and Eagle Project

Paige asked about the AMSAT membership renewal form and made several suggestions including that we enclose a SASE. Saragovitz retorted that some of these suggestions were already in place although we do not provide a prepaid envelope for returning the form. Clark added that it would be still better if members could renew online. Paige offered the suggestion that there be an item on the Web page to renew or join.

Tynan requested that the subject return to the current agenda item, namely, in the light of the present financial situation including our membership trends what do we do with regard to Eagle? Saragovitz called attention to the possibility that for the Echo project, it may be necessary to take another $150,000 out of our reserves by the end of this year although the accountants have recommended against withdrawing any more. Haighton announced that, as of March 2, we have a fund balance of $589,000. Tynan added that is after we make an initial payment on Echo. Daniels noted that another payment will be required soon.

Haighton emphasized that there is nothing to stop us from beginning the design and full study of Eagle, bearing in mind that we want to avoid making modifications during construction and integration. We want to design the satellite to the point where we can, pending the discovery of any major problem, put it together without making changes. It was agreed that this is a nice

2.4 GHz Ant. & Preamp for AO-40 or ATV



DEM 13LNAH Preamp
Ant. mounted, .6 dB NF
15 dB gain.....**$125**

Andrews 26T-2400 Dish 24 dBi....$149 del
Rugged 2 x 3.4 foot cast magnesium/aluminum dish.
50 Ohm feed with N plug. Clamps up to 2" dia. masts.
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idea but we have never been able to accomplish it in the past. The AO-40 experience was cited. Haighton estimated that 18-20 months are required for the design and development of Eagle to the point where the design can be frozen. Wood commented that it would not cost a lot to carry on in this manner. Tynan agreed that we should do considerable amount of thinking before actually building anything.

Daniels offered the opinion that another advantage to scheduling the designing first is that it would avoid bad decisions that might otherwise be made if we move into fabrication too quickly.

Tynan offered the opinion that we can count on Wood to be frugal and to keep the Board informed as to progress and problems. General agreement was expressed to this statement.

Haighton added that we must leave our options open of looking at launch possibilities and the likely need for some form of propulsion.

Baines stressed that members will want to know the time frame for completion and launch of Eagle because they have heard about it, and its promise. Saragovitz urged that this information be made known now, and not wait until these proceedings appear in *The AMSAT Journal*. Haighton said he would send this news to ANS and Journal editors. Paige suggested that the release first mention Echo and then Eagle. Tynan suggested that Haighton send the press release directly to amsat.bb as a special bulletin rather than to ANS so the news will get to members and non-members directly and quickly. He added that it could be sent today to amsat.bb and it would appear a week later on ANS. Saragovitz noted that ANS is sent only to those who subscribe.

Clark advised that a project only achieves reality when it has a launch opportunity. The problem with Eagle is that no suitable launch has been identified, and much of the work cannot be done until you know what the ride looks like. He added that the press release should emphasize that Echo has a promising launch opportunity while Eagle does not. Daniels noted that because Echo is small, there are a wide-range of launches available for it.

Baines asked how long would it take to build Eagle if a launch opportunity appeared tomorrow considering there is an 18-month design process? Wood replied that it would take at least a year to build and Baines concluded that would put it in the 2005-2006 time frame.

Tynan then suggested that the Budget be adjusted appropriately to reflect the new Eagle approach, noting that the important thing is that the $220,000 originally budgeted for Eagle for this year, has now been reduced to $20,000. Feller said that the exact amount is not clear and suggested that he and Wood confer and return with a specific proposal. Saragovitz asked if the expenditures are to be reduced to $20,000 what is the realistic amount of income expected and shouldn't it also be adjusted? There was general agreement to this proposal.

Haighton stated that Eagle should be dealt with on an 18-month basis and that we should make this known to our members.

Haighton asked Hambly when his article on Echo will appear and if the actions taken here will require that changes be made in it? Hambly said he will replace the photographs and ask Kanawati for further information but no changes to the text may be necessary.

Haighton moved that the Board endorse the proposed revision to the Eagle Project schedule, whereby the design stage will begin immediately and last for 18 months; the budget to support this to be adjusted appropriately. Meanwhile, an active search for a suitable launch will continue.

IV. Report on Progress Toward Resolving Impact of Certain Government Regulations

VP for Government Liaison Perry Klein presented his report in a closed session. This report indicated favorable progress in this area.

V. Public Relations

The open session resumed with a review of the progress on having the Microsat model that had been held by Interferometrics, donated to the Smithsonian Institution. It was noted that this had not yet taken place. Tynan recalled that he had recommended that Klein proceed to make the necessary arrangements to accomplish that and to have it put on display. Hambly asked if he might take the model to the Dayton Hamvention before the transfer occurred, noting that it would be a useful accompaniment to the announcement of the Echo satellite project. Klein indicated that it could be made available for that. Saragovitz commented that Bob Bruniga had given permission to display the PCSat model and Hambly said he would transport both to Dayton as well as items for the ARISS display. Clark suggested asking Lorenzini for permission to also take SpaceQuest's model of SaudiSat.

VI. Overview of Future Board Member and Officer Responsibilities

The next topic considered was a presentation by the President of his thoughts concerning future Board member and officer responsibilities. He cited his unsuccessful effort to find an Executive Vice President who would be willing to assume the presidency in about two years. He believes this is due to the reality of serving as President takes a lot of personal time and many potential candidates are employed full time that precludes their serving because the pressure currently being put on employees has markedly increased. Although there are benefits of being President, they are chiefly in the area of ego support. It is mostly a one-person job and requires setting up your own office and supplying your own equipment. Referring to the AMSAT Bylaws defining the many duties of the President, Haighton said it amounted to being the CEO of a membership organization with thousands of members and is a full time job - 7 days a week with more to be done on weekends and evenings. He noted that the Corporate Secretary/Manager job is also full time and although it assumes some of the responsibilities, requires frequently consulting with the President. He then stated that this situation must change and the Board members must share the President's load if AMSAT is to find a replacement whose is up-to-date, presently active in the workplace, knows modern techniques and is younger than the rest of us. He mentioned a recent discussion with Baines on this subject who gave several reasons that included a possible conflict of interest, why he could not assume the office of Executive VP. Haighton said he then realized that most of the Board members are also officers with AMSAT responsibilities so they are already sharing the load. He then declared that for the remainder of his tenure as President he did not object to maintaining the current situation but he does want to be certain that the position will be attractive for future presidents. He has sought advice on how someone active in the work place could accommodate those responsibilities as well as those of the AMSAT President. One suggestion was to centralize email whereby each Board member and officer will look twice a week at mail sent to the President and reply to those messages they feel best qualified to handle. Hambly noted that such replies would show where they came from. Haighton replied that it is common practice to state "the President has asked me to reply", or some such verbiage. He added he may get 20-30 messages in a day or as few as two to three. Baines agreed with the idea of

having a central email answering facility because it makes it easy to share information, but his concern is that if there is a sizeable group responsible, no one will take the responsibility of replying. So, he suggested that each piece be forwarded to a specific individual. Discussion followed with Tynan saying that Haighton will still have to read and understand the message in order to know to whom to forward it. He agreed, however, that such an approach should require less time than for the President to answer each and every question. Haighton said that he intends to go ahead with this plan now that he has appointed an assistant who has experience in using this type of referral system and will be able to develop it for AMSAT as well as handle some of the task himself. Paige suggested referring those wanting information to the list of officers on the Web page and to direct their question to the VP of the appropriate department. Tynan asked that this be brought up again when the Web site is discussed. Saragovitz commented that a lot of mail comes to the office with questions. She said that she routinely forwards such mail to an appropriate Board member or officer.

Haighton then reiterated his frequently repeated statement that each officer must identify his potential successor. This, he emphasized, becomes an important aspect of the referral mechanism. He would like to begin calling these persons "Assistant to the VP." He further stated that the titles and responsibilities of the Board-appointed ("Big O'") officers be reorganized. He asked for ideas on how to equalize the work because some officers are burdened with more commitments than others. Saragovitz pointed out that this would require a change to the Bylaws to which Haighton replied he understands that. Tynan added that the Bylaws stipulate what "Big O's" exist in the organization. Haighton said he wanted to make the changes because we may want to add a major VP running the public relations and publicity aspects of the organization. The question then arose as to why this office had to be a "Big O". His reply was that he needed new ideas and new people coming on the Board. Admitting that some of these ideas were controversial he added there may also be a need to have term limits for Board members. Soifer noted that a careful reading of the Bylaws reveals that the founders chose to give the Board as much discretion as they could. Haighton said he did not intend that the assistant to the President should be a "Big O" and noted the Board elected the President and could fail to reelect if unsatisfied with his performance. Paige mentioned several disadvantages to term limits for directors, one of which is that we might end up with a very inexperienced Board. Haighton replied he was thinking of 3 to 4 terms as the limit. Saragovitz opined that the Board members are elected by the membership and it should be up to them to choose whomever they want. Haighton replied that the membership is unlikely to ask the kinds of questions and that's why he was asking them. He then asked if there should be something like a Council of Past Presidents established to provide advice and assistance to the Board? Paige replied that this already happens. Tynan agreed saying he would be opposed to formalizing such an arrangement. Haighton then asked if there should be a limit on the term of the President? It was restated that the Board has the power to continue or discontinue the President's term. Haighton asked if Board members should automatically be assigned "Big O" responsibilities either by the President or the Board? Baines said the basic question is what is the responsibility of being a being a Board member vs. being an officer in the organization. He said the two issues he sees is 1) people get elected to the Board to serve as Board members not to serve as officers and 2) there is a Chain of Command issue if a Board member becomes "Big O" by election. The Board holds the President accountable for running the organization. Thus, there is potentially a conflict if Board members are automatically officers. Who would be responsible to whom and how would you separate these responsibilities? Clark mentioned that in earlier days there was confusion between Board functions and officer functions. By the time of OSCAR 8 it was finally realized that it was necessary that some would serve as both, so after some soul searching in about 1980, it was realized that we had to start separating the functions. Saragovitz recalled that at one time the VP for Engineering was dedicating his efforts almost exclusively to building satellites and did not recognize his major responsibility as a Board member, though he was one. She added that it's the Board that must control the finances. Haighton then asked if the "Big O's" should be elected by the membership? This was discussed and Saragovitz opined that making some of these changes would make the organization too bureaucratic. Tynan stated that those who get elected to the Board generally have enough wisdom to know what qualifications are needed of the various officers and the membership in general may not know the people well enough to make such decisions. Baines said the fundamental issue is that "Big O's" are elected by the Board and have a dual responsibility, first to the Board because they elected him or her, and second to the President who is running the Corporation. He then asked if someone is elected by the membership, to who is that person responsible and how would the President or the Board control the organization if you have persons independently elected? Several viewpoints were expressed and it was agreed that this is weighty issue needing much more discussion and thought before any changes are proposed.

Clark returned to the subject of term limits noting that one of the problems with our election process is that, if a good person appears and is nominated but does not have the name recognition of the other candidates, it is usually difficult for that person to be elected to the Board. He noted that he has served many terms on the Board and has tried several times to get off but has been told his experience is needed. Discussion followed with Tynan agreeing. Saragovitz noted that in January Clark will have served 25 years and stated that the only way someone new gets on the Board is when a current member resigns or does not run. Then, the person with the widest name recognition, gets elected. Haighton said this was his motivation for raising the question of term limits although he recognized that those who have served a long time have a lot to contribute.

Clark added that another consideration is that, while we have members who draw their interest from the social interaction of using the satellites to make on the air contacts, there is a smaller faction of members who are *technical dreamers* who actually build things for spacecraft, yet never get on-the-air. He noted that some of those present fit that description. He added that these *tekkies* have had more clout because, if there aren't any satellites, there's nothing for the users to use. So, they realize that they need the technical types. "Now," he continued, "that kind of thought has to be threaded through here." The reason he said he "has steadfastly agreed to run for the Board is because he can bring in part of the *teckkie* point of view that is needed to balance the enthusiasm of those enjoying operating achievements. It presents a dilemma," he concluded, then added "someone from the operations side could make the same claim so both groups need to be accommodated."

Baines stated the Board needs to talk about the two issues raised by Haighton i.e., the purpose of the Board and its policymaking dealing with elections. The second issue is how to spread the workload around among the officer levels to create an environment where those, other than a retiree, can effectively assume the Presidency. Haighton replied that one of his answers was to have all

the officers train their assistants. Baines opined that the question is; are the things the President does, things only the President should do, or are other things that can be delegated?

Tynan asked if there is a current possible resolution to this question? Haighton replied that he was pleased to have received the Board's inputs. Tynan noted that many of the comments deal with things the group does not want to change but added that there does seem to be general agreement that answering the email should be delegated to others, and that several viable suggestions were presented regarding how to accomplish this. Haighton declared that we should come up with more ideas at future meetings. Clark mentioned that the questions that came up often have been asked before and he suggested these answers be included on an easy to use URL. Tynan suggested deferring discussion of this to the next day's agenda item dealing with the Web page.

Haighton recalled that AMSAT had been started by a group of young, highly principled and successful engineers and he asked if the organization can be rejuvenated with that type of person? Tynan opined that age has little to do with it, we're now older and still have bright ideas. Clark expressed concern that we've not been very successful in bringing in new persons regardless of the approach tried so the median age is still increasing and many are past the "age of expectation." Although it was agreed that the ham population is getting older, Clark said there is a notable increase in younger persons becoming hams with the advent of the no code license. Tynan agreed with these statements but doubted that this discussion would lead to anything useful here. Haighton reiterated his appeal for relevant ideas dealing with these topics be sent to him soon and so action should be taken now, not five years hence.

VII. Review of the AMSAT Financial Position in the Light of Echo Commitments, Fund Raising Prospects and Other On-going and Proposed Activities

Feller reported that the revised budget for the Eagle project had been completed. Total expenses for the project for the year are projected to be $12,750. He added that after the changes the overall income to AMSAT from all sources is estimated to be $422,600 and total expenses to be $573,000. So there is a projected deficit of $151,000. He noted that this includes the Echo spacecraft project. Feller said he'd send the detailed Budget to Board members by email.

Clark moved that this revised budget be accepted. Paige seconded and it was passed by a unanimous vote.

Feller added that expenses for management and overhead amount to approximately 9% and about 11% for fund raising, so approximately 80% of the expenses go for our satellite programs. All agreed that this is a good situation, and that the membership should be made aware of it.

VIII SpaceQuest Contract

Tynan then asked for a discussion of the details of the contract with SpaceQuest. This was carried out in a closed session.

The meeting was then adjourned for the day at 5:30 PM.

IX. The AMSAT Internet Facility and Web Page

Upon reconvening Sunday Morning, 21 April 2002 at 9:31 AM, Tynan opened the session stating that the AMSAT Web site would be first item discussed. He indicated that he would like to see important items more readily accessible on the Web site. For example, he explained he always has difficulty locating the IARU Guidelines for Perspective Builders of Amateur Satellites. This, he said, has presented problems when dealing, especially with out-of-US people wanting OSCAR numbers for their spacecraft. He said he refers them to the Guidelines but many come back, unable to locate them.

This generated a protracted discussion on various ways to improve the page. However one point was clear. That is that Paul Williamson is doing a fine job running the page. Anything that might be suggested would be in ways to assist him. Martha made the point that he quickly gets things onto the page, once they are sent to him.

It was finally decided that Tom Clark would be designated to discuss with Paul various ways of making the page still better. The following specific action items were agreed-to:

1) Haighton will ask Mills to send the latest AO-40 information to James and Williamson,

2) Baker will update press releases,

3) Haighton will form a committee, managed by Baker, to come up with ideas for Clark to suggest to Williamson,

4) Clark will contact Williamson regarding:

a) the general problem of indexing,

b) a way to improve timeliness including having a volunteer to handle getting information to him.

c) ask Williamson if he would like someone to assist him, and if so, who?

X. Distribution of Monthly AMSAT Financial Reports via Email

Ways to implement the electronic distribution of the AMSAT Financial Report were next discussed. After a short discussion of the digital format, Paige suggested a way to have the text appear looking like the printed version and offered to handle this if Martha would send him the basic information. She maintained that Bob Carpenter should be allowed to select the format and that preparation of the Report should be the responsibility of Feller and her. Page agreed to this and again offered to handle distribution of the report in pdf format. For this, the Board thanked him. Saragovitz said that the Merrill Lynch securities statement will continue to be sent by paper mail but only to Haighton, Baker, Soifer and Feller. Saragovitz will henceforth send the Financial Report electronically to Paige who will convert it to pdf and distribute it the Board members plus Frank Bauer.

XI. Cooperative Arrangements for Distribution of *The AMSAT Journal* by Overseas AMSAT Organizations

Haighton announced that he had been approached by Chris Hill of AMSAT-Australia, who advised that distribution of their publication had ceased; and, as a result, they had lost members. Therefore, Hill suggested that we send our *Journal* electronically to them for subsequent electronic distribution to AMSAT-Australia members. Haighton noted that the *Journal* is already in electronic form for transmission to the printer, so this should not represent a significant burden. AMSAT Australia would pay a fee for each copy they distribute.

Clark commented that, in the past, we have encouraged other AMSAT societies to use our publication as their official journal and that it had worked satisfactorily in some cases. He said he saw no problem in using our *Journal* this way. However, he cautioned, we have not yet come to grips with the overall problem of electronic distribution. He further noted that a paper *Journal* arriving in the mail has been recognized as inducement for membership; and added, that as soon as we give it away electronically to even one person, it's gone to the world. Even though we might try to employ some sort of security there is nothing to stop anyone receiving it

from sending copies to any number of friends. Therefore, we have lost control of it. Paige pointed out that members can already make copies either by copier or scanner. Clark agreed but emphasized that once it is in digital form, it is much more likely to be distributed digitally by others.

Haighton commented that with regard to Clark's comments, we could try the system out in a remote corner of the world to see if it's workable. Clark suggested instead, sending it digitally to one individual in Australia who would then have it printed locally and mailed there. He noted that's what many commercial magazines do. Tynan agreed that receiving a paper *Journal* in the mail has more impact than an electronic document and asked Haighton if this possibility had been mentioned to Hill? Haighton replied that Hill was planning to look into that, but the problem is that he may not have the time or capability to have 400 copies printed and distributed. Paige commented that this approach does not solve their problem of not having enough members to pay for the printing and mailing such a small quantity.

Tynan offered the opinion that electronic distribution is not likely to increase their membership. Saragovitz agreed with Clark that making the *Journal* available for electronic distribution would result in it being sent out by others and she cited the case of our copyrighted *InstantTrack* software that may be found on various bulletin boards outside the U.S. Also she opined that it would be unfair for the digital version to appear in Australia before those who receive a printed copy. Haighton replied that transmission of the digital version could be delayed sufficiently to take care of that. Saragovitz then suggested that the situation existing in Australia might also occur in other counties. Haighton replied that the advantage to his suggestion is that it can be done on a trial basis and if doesn?t work, it can be discontinued at any time. Clark hypothesized that anyone anywhere who preferred an electronic version might join AMSAT-Australia rather than AMSAT-NA. Haighton said the trial program would reveal if this was the case. Saragovitz commented that we would certainly lose most of the AMSAT-NA members living in Australia if such a scheme were begun. Not all those present agreed with this opinion.

Clark stated that publishing is an evolving field and electronic distribution will become the preferred method for a large number of persons so eventually we may want to go that way. However he said he would be reluctant for the Australians to have this advantage over the other members. So, we should try to predict the big picture over the next 5 to 10 years. Then, the Board may be in a better position to decide whether to evolve into full electronic publication, and determine how to do it.

Haighton reiterated that this test market approach would gain us experience with electronic distribution, before we attempt to launch it in North America. Soifer said that the rest of the world isn't familiar with test markets but they would quickly learn that we have an electronic version. He added that in the business world the problems of electronic publication have not yet been solved and until they are, he advised that we proceed slowly.

Tynan reminded the Board that it has previously debated the question of publishing an electronic version of the *Journal*, and decided that, if we did, we would probably lose members who prefer to receive something in the mail.

Page opined that everything is going digital and it's not realistic to think we will continue to have a printed *Journal*.

Tynan renewed the suggestion made earlier that the *Journal* could be sent to Australia electronically with the stipulation that it be distributed by there only in a paper version.

Saragovitz expressed concern that, if dues to AMSAT-Australia are less than ours, there will be no incentive to join or remain a member of AMSAT-NA. Tynan said we are glad to have foreign members but we are not the World's AMSAT organization and we don't want to compete with those local groups that in many cases we helped to get started.

Haighton stated that if we want to continue to have people in Australia, like Graham Ratcliff who helps run the telebridge, we need to support them and those in other nations as well who are part of the AMSAT family. Tynan said that our handling of this situation will provide a model for the next national society which may ask for similar assistance. Soifer suggested that Haighton go back to Hill and offer two alternatives, with prices to be negotiated. One would be to provide one copy for them to print locally and the other to bulk mail to him as many copies as he wants and he will be responsible for distribution. Haighton said that alternative has been considered and found too expensive as well as making extra work for our office. He also questioned whether their local printing costs would be reasonable. Soifer offered to obtain an estimate of what their printing costs would be.

Clark suggested that this was an excellent problem for a Publications Committee and suggested that one be formed to consider the entire subject, including all the technical aspects as well as other considerations. There was general agreement that this should be done. Haighton said he had already started a dialog with various people on the subject and would continue to follow up.

Haighton also said he will contact Hill regarding our deliberations on the matter, but expressed disappointment to find there were so many objections to making the proposed arrangement.

Paige brought up the related topic of how to increase the number of AMSAT-NA members. He said it has been established that the numbers are declining so we have to provide an incentive to recruit new members and to retain those we have. He proposed a contest of 6 months duration wherein present members who recruit new members will have their names placed in a drawing for prizes of ham equipment. He offered details of how this might be done. He added there could also be a follow-up contest with incentives to renew. Tynan noted that this was a good idea, but we've already done it and it worked reasonably well. Saragovitz added that when Baker was President we offered free software to new members but most of them failed to renew. Tynan stated that this item doesn't require discussion by the Board and he is confident the officers can handle it.

XII. Report of the ARISS Committee Meeting Held in Montreal

Haighton reported on the ARISS meeting held 04-06 April 2002 in Montreal, Canada. He noted that this was the first time the Committee has met in Canada. There was wide representation including persons from several European countries, Canada, USA, Japan plus Russia. Observers included McFadin from AMSAT-NA, Paul Middleton from Kenwood, persons from the Canadian Space Agency and Bob Bruninga (by telephone).

Haighton said that the meeting included discussion of a thorny issue that had plagued ARRIS last year. To resolve the dispute, Frank Bauer called a worldwide telephone conference among the Committee members. In that telecon, it was decided then that Bauer would make a presentation to the joint committee of NASA and the Russian Energia, the senior management group having responsibility for the entire ISS operation. This resulted in an agreement that has since allowed the project to proceed as it was doing.

• Following Haighton's report, discussion of various ARISS issues took place,

• The ARISS Hardware Committee was renamed the Project Selection Committee.

• Appreciation was expressed to Lou McFadin for his antenna work on the project.

• A program was discussed involving Naval Academy cadets working in conjunction with ARISS.

• Tynan suggested, as he has done previously that specification documents be prepared stating what equipment is needed, what its performance should be and what limitations would be placed on it. He said that he has always felt that such a document, distributed to industry would produce a number of proposals to supply appropriate equipment.

• There was also extensive discussion concerning the publicity ARISS is receiving vs the exposure AMSAT-NA derives from it.

XIII. Miscellaneous Items

A discussion followed concerning the role and mission of the AMSAT-NA Projects Committee. Clark announced that he has heard some concern expressed that some AMSAT members are also being paid by SpaceQuest for their efforts. Other examples were given of those who have furthered their livelihoods as a result of the work they are doing with AMSAT. Haighton acknowledged that a few of our most talented members are receiving compensation for their work on other project, but maintained that this is not a bad thing.

Baines asked about the status of the Business Development Committee, to which Haighton replied that he believes this is an important group. He stated he was particularly happy to have been able to appoint Walter Wittenberg VP for Development. He added that he plans to meet with him at the Dayton Hamvention.

Tynan asked about Haighton's newly appointed Assistant to the President. Haighton replied that he was Barry Delong, a member of the Burlington (Ontario) Amateur Radio Club and, although not previously known to him, had good references and had been an early responder to the recent Skills Survey. Before retirement Delong owned a computer business and is presently helping Haighton with paperwork.

Tynan mentioned a recent volunteer in Kerrville, Texas who is a retired electronic designer and emphasized that we must continue to try to recruit new people of all skills. Haighton reiterated his earlier charge to the officers to find assistants who can take over their office if necessary, and to Board members to continue to look for new volunteers for various tasks.

XIV. Review of Action Items

1) Daniels will speak to potential launch agency representatives.

2) Daniels will contact Rick Fleeter of Aero Astro.

3) Wood will investigate microwave propulsion systems.

4) Haighton will meet with Martin Sweeting regarding various launch possibilities.

5) Wood will investigate the location of the SBS tooling table.

6) Feller will arrange to split the rental cost for the Orlando facility between the ARISS and Eagle projects and reduce the income estimate for the new Budget. (Accomplished during the meeting)

7) Klein will negotiate with the Smithsonian Institution regarding the donation of the original Microsat model.

8) Haighton will ask Stacy Mills to send the latest AO-40 information to ANS and *The AMSAT Journal*.

9) Baker will update press releases.

10) Baker will establish a group to discuss potential changes to the AMSAT Web site. These will then be discussed with Clark who will act as liaison with Williamson.

11) Baines will contact Mike Seguin for satellite updates to include on the Web site.

12) Saragovitz will send the Financial Report to Paige who will distribute it electronically to Board members plus Bauer.

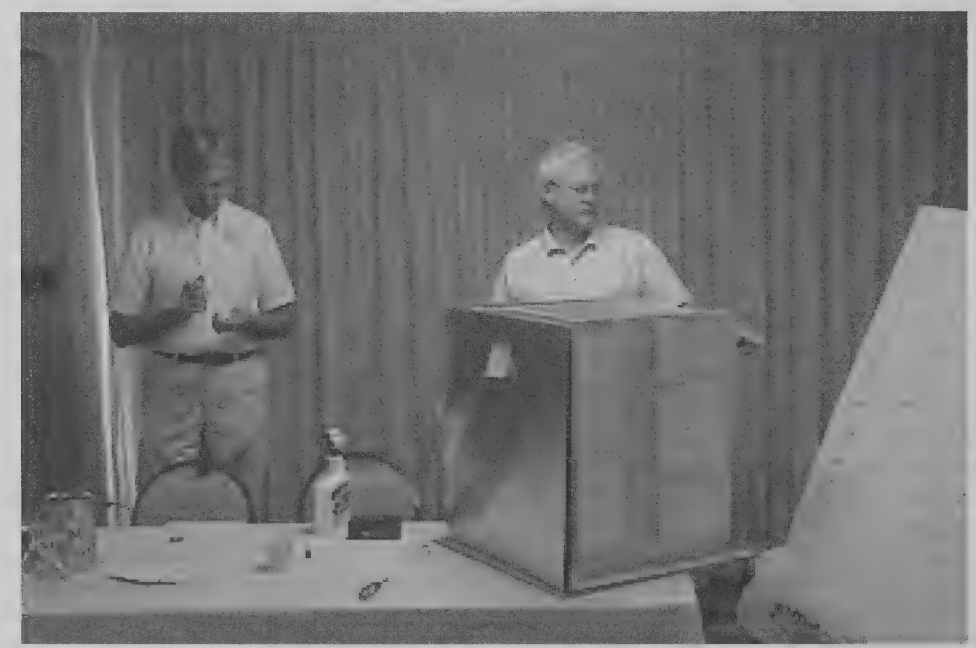
13) Haighton will talk to Chris Hill about redistribution of *The AMSAT Journal* in Australia.

14) A committee will be established by Baker to consider electronic publication of *The AMSAT Journal*.

15) Saragovitz will contact Will Marchant about publishing an article about ARISS in the *Smithsonian* magazine.

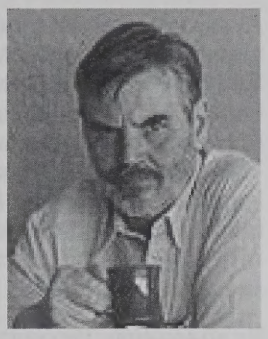
XV. Adjournment

Paige moved to adjourn and Tynan declared the meeting adjourned at 1:30 PM. He announced the Board will reconvene by teleconference as the need arises.■



Putting It All Together. Stan Wood, WA4FNY and Jim White, WD0E coordinate the layout of *paper modules* on an fullscale Eagle prototype model at the recent Eagle Workshop held in Orlando, Florida during September 2002. As a result of this key exercise, a considerable portion of Eagle systems were validated for design and development.

Thomas Kieselbach, DL2MDE Silent Key



ANS has sadly reported the passing away of Thomas Kieselbach, DL2MDE on October 8th, 2002. Thomas was sailing on his yacht with his wife Gaby, when he suffered a fatal heart attack. They were in the Aegean, near the island Kos. Gaby managed to steer the yacht safely to harbor. Thomas' groundbreaking work in the arena of Amateur Radio in the manned spaceflight programs set the stage for the success the ARISS program now enjoys.

Frank Bauer KA3HDO, ARISS Chairman, says it best. Frank said, "On behalf of the ARISS International team, I would like to express my sadness in the loss of a true friend and outstanding technical ham, Thomas Kieselbach DL2MDE.

Personally, I first learned of Thomas' outstanding technical abilities in 1985 during the STS-61-A German Spacelab-D1 space shuttle flight. During this mission, he flew the first set of German amateur radio hardware on a human spaceflight. The Germans called this system SAFEX. This was a system he personally built and it had outstanding capabilities. One of the most impressive parts of this system was the external antenna that was mounted on the outside of the spacelab module. Only Thomas, with his intense drive, could break through the human spaceflight barriers to get an antenna feedthrough. He was the first to fly an external antenna on a human spaceflight program. Through his efforts, he blazed a trail for Mir and ISS.

He then extended his work to the first Shuttle flight to have U.S.-built and German-built amateur radio hardware on-board. This was the STS-55 German Spacelab-D2 space shuttle flight in 1993.

As one of the founding delegates of ARISS (Amateur Radio on the International Space Station), he challenged our team to push the technical limits of amateur radio in space. We thank him for his technical ideas and vision. His vision to have a full-duplex radio system that transmits both the radio uplinks and downlinks to the ground will be on ISS in the future.

To all Thomas' friends and family and especially his wife Gaby, we extend our condolences."

AMSAT-Eagle Team Meets to Forge Design

A meeting was held in Orlando, Florida the weekend of 28-29 September 2002 to develop and coordinate design plans for the AMSAT-Eagle satellite. As a result of this meeting, significant progress was made in verifying Eagle's mission and design as well as clearly identifying and assigning responsibilities and an associated time schedule for developing this satellite. Plans call for AMSAT-Eagle to be placed in a highly elliptical Earth orbit with a spin axis in the orbit plane to allow wide-area amateur radio communications coverage. While Eagle is being built for launch in a 2004-2005 timeframe, a specific launch opportunity has not yet been secured for Eagle.

Resultantly, Eagle is being "generically" designed with the intent of remaining flexible for use on a variety of geo-stationary transfer orbit (GTO) launchers. It is anticipated that it will take one year to construct the prototype space frame and modules for Eagle. After construction, Eagle will undergo intensive tests to verify readiness for flight.

Since the initial Eagle design meeting held in Denver, Colorado last July 2001, much progress has been made on the satellite's structural space frame and thermal design. As a result this work, Eagle's shape and dimensions have been identified. This will allow, if necessary, for Eagle to be placed on an Ariane 5 ASAP ring as a secondary payload allowing insertion into a highly elliptical GTO. Once in orbit, it is proposed that high-gain antennas and one transmitter will be used at apogee while more than one transmitter (exclusive of C band) using omni-directional antennas would be used during perigee. In addition, initial thermal analysis has been performed on Eagle's design and orbit showing that when in a spin axis in the orbit plane, the spacecraft will experience acceptable operating temperatures ranging from 5-30C degrees. Meanwhile, it is anticipated that Eagle's bus will provide an average of 90W while the transmitters will be agile to take full advantage of all available power. While Eagle's exact power output remains to be determined, this power input, from solar cells, should allow transmitters to provide good links throughout its orbit. Also, a Communication and Digital Processing Experiment (CDPE) will provide a small suite of DSP and hardware digital modems for digital communication experiments.

As a result of these design efforts, meeting participants were able to identify the following tentative specifications for the components, modules, and systems necessary for Eagle to carry out its primary mission of amateur radio communications.

Project Eagle Specifications R5, as of October 3, 2002:

1.0 Mass: 100 kg or less
2.0 Size: 600mm cube with fixed and deployable solar panels
3.0 Attitude: Spin stabilized (+Z nadir-pointing at apogee)
4.0 Orbit:
4.1 Initial orbit GTO (200km perigee)
4.2 Final orbit GTO with perigee greater than 500 km
5.0 Attitude Control:
5.1 Magnetorquers
5.2 Sensors:
5.2.1 Sun
5.2.1.1 Two dual slit (similar to P3D, top and bottom) offset by +/- 40 degrees
5.2.1.2 Two stable-mode offset 5 degrees from +Z and +Z axes
5.2.2 Earth
5.2.2.1 Two narrow FOV ~4. Offset from X-Y plane by TBD
6.0 Thermal Control: Passive
7.0 Power System:
7.1 Two fixed and four deployable solar panels with omni coverage
7.2 One battery control regulator (BCR) per panel with synchronized control (similar to Phase 3D). Grouped in banks of three. Failure tolerant
7.3 Bus Voltage: 28VDC, Solar panel voltage 28V.
8.0 High gain antennas on +Z side
9.0 Separation interface and Omni antennas on -Z side.
10.0 Propulsion system Mono-propellant. On -Z axis.
11.0 Structure:
11.1 Aluminum/carbon fiber honeycomb panels forming core structure supporting internal modules and integrated with separation interface
12.0 Separation Interface:
12.1 Launcher dependent
13.0 Housekeeping:

13.1 Am1601 processor
13.2 Temperature, ~TBD channels
13.3 Pressure, ~TBD channels
13.4 Current, ~TBD channels
13.5 Voltage, ~TBD channels
13.6 Module control via Controller Area Network (CAN), internal power switches in modules
14.0 Antennas:
14.1 High Gain +Z
14.1.1 2m, 70cm, L, S, C
14.2 Omni antennas, -Z
14.2.1 2m, 70cm, L
15.0 Payloads
15.1 Transmitters
15.1.1 V band (145MHz)
15.1.2 S band (two 2.4GHz)
15.1.3 X band beacon (10GHz)
15.2 Receivers:
15.2.1 U band (435MHz)
15.2.2 L band (1.2GHz)
15.2.3 C band(5.6GHz)
15.3 GPS (NASA)
15.4 Cosmic Energy Deposition Experiment (CEDEX) via Surrey Satellite Technology
15.5 Communications Processor w/AO-40 compatible DSP
15.6 Cameras, two wide dynamic range:
15.6.1 Narrow FOV on +Z axis
15.6.2 Wide FOV on -Z axis
15.7 TLM beacons on all transmitters
15.8 Command uplinks on all receivers
16.0 Magnetically clean
16.1 Back wire solar panels
16.2 Balance solar panel wiring loops
16.3 'Tune out' any permanent magnets
16.4 'Tune out' any solenoids
16.5 Degauss magnetorquing rods

Future News on Eagle

The Eagle team welcomes AMSAT member participation in the development of this satellite. To better coordinate information on satellite development and to seek membership oversight, Russ Tillman, K5NRK has been assigned as communications officer for AMSAT-Eagle. Presently K5NRK is working with the Eagle team to develop a communication plan that will use the variety of AMSAT news sources to relay various information about this satellite to AMSAT members and other interested parties. As a result, it is anticipated that this communication plan will allow AMSAT members not only to better follow Eagle developments but also allow them to be aware of when they can provide timely and coordinated assistance as well as make plans for its use. In addition, it is hoped that this communication plan will serve as a model for future use in relaying information about other AMSAT projects and identifying and encouraging membership participation.

Eagle at Fort Worth

Several papers pertaining to AMSAT-Eagle will be presented at the 20th AMSAT Space Symposium and Annual Meeting scheduled to be held in Fort Worth, Texas on 8-10 November 2002. Included on the agenda is a presentation by Dick Jansson, WB4FAB on the space frame design of AMSAT Eagle. In addition, the Eagle development team will use Fort Worth venue as an opportunity to meet and discuss progress to date and any specification revisions. This meeting is tentatively planned for 0800-1200, Sunday, 10 November 2002.

AMSAT Eagle meeting participants included:

Robin Haighton, VE3FRH
Rick Hambly, W2GPS
Bdale Garbee, KBOG
Chuck Green, N0ADI
Dick Jansson, WD4FAB
Lyle Johnson, KK7P
Lou McFadin, W5DID
Russ Tillman, K5NRK
Jim White, WD0E
Stan Wood, WA4FNY

Further information on the results of this meeting as well as news on future development of the AMSAT Eagle project will be made available via AMSAT WWW, The AMSAT Journal, ANS, and other sources.

Texas Youngster Makes Career Choice During ISS Ham Radio Chat

Fourth-grader Kyle Bryant made a career choice this week. He's going to become an astronaut. At least that's what he told his teacher, James Jones, after he and nine of his classmates at Lamar Elementary School in Greenville, Texas, fired off questions via ham radio to astronaut Peggy Whitson, KC5ZTD, aboard the International Space Station. The contact was arranged via the Amateur Radio on the International Space Station (ARISS) project.

Kyle and his classmates at Lamar Elementary have been studying space and space travel for weeks in preparation for the ARISS QSO. Jones called the 10-minute experience "absolutely phenomenal," and added that it was "mind boggling" for his students to actually talk to Whitson after studying about her and her two crewmates, crew commander Valery Korzun, RZ3FK, and cosmonaut Sergei Treschev, RZ3FU.

"We've been tracking them for days on an Internet Web site," Jones said. "This was very impressive! It made a bunch of kids very happy!"

Lamar Principal James Evans explained that since his school's new campus opened in August, the emphasis has been on science and space. "Every classroom has a display having to do with space," he noted.

Amateur Radio coordinator for the direct, 2-meter contact was Art Passannante, KC5GQP. He and his crew from Greenville set up their station outdoors in front of the school to accommodate a sizeable audience. The quad beams for the contact were homebrewed in classic ham radio fashion from scraps of all-thread, plastic pipe and wire salvaged from the trash pile at a construction site.

By all accounts, the contact went flawlessly. Among the onlookers were some 100 students, 20 parents, a dozen or so teachers and three reporters.

ARISS is an international project with US participation by NASA, ARRL and AMSAT.

[Via The ARRL Letter Vol. 21, No. 41 and Gene Chapline K5YFL for the above information.]

ARRL, IARU Continue Push for Limits to 70cm Spaceborne Radars

A just-completed draft revision to an International Telecommunication Union (ITU) Recommendation could result in reining in the potential for interference to amateur and other services from synthetic aperture radars (SARs) on 70 cm. Agenda item 1.38 at World Radiocomunication Conference 2003 (WRC-03) will consider a request to allocate up to 6 MHz of spectrum for SARs in the band 420 to 470 MHz to be operated by the Earth Exploration Satellite Service (Active) — EESS-Active. At issue is whether the EESS allocation could be established without interfering with incumbent services, including radiolocation and amateur.

"ARRL and IARU (International Amateur Radio Union) will continue to oppose SARs operating in the most active portions of the amateur 70cm band," said ARRL Technical Specialist Walt Ireland, WB7CSL. The spaceborne SARs would be used to measure soil moisture, tropical biomass and Antarctic ice thickness, and to document geological history and climate change. EESS proponents contend that the best center frequency to penetrate jungle or forest canopies is 435 MHz.

"There is some hype starting up at this late date that gives the impression that the sky is falling," Ireland said, referring to recent reports in the amateur radio news media that, among other things, incorrectly claim that EESS proponents are seeking "exclusive

use" of 430 to 440 MHz and that the EESS issue is a new one.

While some occasional interference from SARs to amateur systems would appear inevitable, Ireland said, efforts to minimize the impact of the EESS (Active) operations have been under way for several years. "Although the SAR interference criteria limitations in the revised Recommendation SA.1260 automatically would eliminate three of the SARs, amateurs can still expect to receive interference from some of the remaining SARs on a limited basis if WRC-03 allocates frequency spectrum between 420 and 440 MHz to EESS (Active)," he continued, "especially if the allocation is made primary." The revised draft would keep four of the proposed SARs and eliminate those with peak radiated power levels from 400 W to 10kW — that is, average power levels above 25 W, he explained.

Work on the major rewrite to ITU Recommendation SA.1260, hammered out by ITU-Radio Sector Working Party 7C over the last several years, wrapped up October 4 following a weeklong meeting. The draft recommendation sets interference criteria limitations for SARs to be operated by EESS (Active) in the 70cm Radiolocation and Amateur and Amateur-Satellite Services band. Ireland represented the ARRL on the US Delegation to ITU-Radio Sector WP 7C. Ken Pulfer, VE3PU, represented the IARU. For the past two years, Pulfer has been chairing the drafting groups that worked on the revision and brought it to its present status — along the way incorporating protection for amateurs.

SARs and the Amateur Service can coexist at 430 to 440 MHz "by taking appropriate technical and operational measures," the draft revision states. The Amateur Service is primary at 430 to 440 MHz in Region 1 and secondary in Regions 2 and 3, which includes the US.

"It should be remembered, however, that an ITU-R recommendation is just that — a recommendation, not a regulatory instrument," Ireland cautioned. He notes that 18 sharing or compatibility studies — in which the ARRL and the IARU have actively participated — have been conducted during the past seven years — eight of them completed in the past two years.

During the Conference Preparatory Meeting next month as well as at WRC-03 next June in Geneva, the ARRL has pledged to maintain its stance against egregious interference from SARs to amateur radio. The US also has expressed opposition to SARs that could interfere with its radiolocation systems in the band.

Earlier this year, the FCC's WRC-03 Advisory Committee and the National Telecommunications and Information Administration's Radiocommunications Conference Subcommittee recommended no change to the Table of Allocations in the band 420 to 470 MHz as the US position. Both panels determined that SAR transmissions could periodically impact amateur reception and even held "the potential for significant interference."

[ANS thanks The ARRL Letter Vol. 21, No. 40 for the above information.]

Packet Changes Announced on ISS

New parameters were loaded in to the PMS as part of a planned procedure. The call sign of the PMS mailbox has changed from RS0ISS to RS0ISS-1. The old call RS0ISS is no longer being used for the PMS mailbox. If you connect to the RS0ISS port all of your data will go into the giant bit-bucket in the sky.

An ISS packet mail system problem has been discovered. There is a minor, yet recurring problem with the amateur radio personal message system (PMS) on-board ISS. Intermittently the PMS will fail to display the list of messages stored in the memory of the PMS. The messages have not been lost, they are still in RAM memory. Miles WF1F reported, "I have encountered this problem several times and each time the problem seems to clear up by itself on the next orbit. If you do encounter this problem please try to avoid uploading any messages to the PMS while it is having the listing bug. Just simply log out and try again on the next orbit." When the problem clears, all of the old mail still appears to be saved in memory without any loss of messages.

Also, for the coming week the ISS packet system plans to change its operating frequency to 145.825 MHz simplex. This was part of a test to take advantage of a dual-hop constellation with PCsat. The objective is to see if the satellites can be used to relay packets from each other to extend the range via a dual-digipeat hop. The duration of the test will be about a week or more depending on the needs of the ARISS radio. If the crew wants to operate voice, they will QSY back to 145.800 MHz.

If ISS users do not hear ISS on 145.800 MHz as usual, they should check to see if it is on 145.825. If so, QSY and operate normally there. UI digipeating of very brief user packets is welcome. The joint pass window for ISS and PCSat are on-line at *http://www.ew.usna.edu/~bruninga/iss-faq.html* The link is in the very first item of this information filled page.

To attempt a dual-hop digipeat users should set their packet UNPROTO setting to UNPROTO CQ VIA RS0ISS,W3ADO-1 if you are in range of ISS, and ISS can see PCsat. Conversely, you are in range of PCsat and PCsat can see ISS, then set your packet UNPROTO setting to UNPROTO CQ VIA W3ADO-1,RS0ISS. Operations through each individual space digipeater should continue to use the usual settings, such as UNPROTO CQ VIA RS0ISS or UNPROTO CQ VIA W3ADO-1 which will not result in a dual-hop. The digipeater aliases for ISS are RS0ISS, ARISS, and WIDE. For PCsat the only reliable one is W3ADO-1.

Bob WB4APR said, "Please do not transmit too much. The probabilities of success are very very limited by QRM, so it would be best if each person only transmitted a few packets a minute and let others have a chance."

Commander Valery Korzun aboard the ISS confirmed the packet frequency change via a packet message:

From : RS0ISS

Subject: THE PACKET'S FREQUENCY OF ISS!!!

WE ARE GOING TO MAKE THE TEST WITH PACKET MODULE VIA SATELITE DURING THE NEXT WEEK. THE PACKET FREQUENCY WILL BE (FOR ISS): UP 145.825, DOWN 145.825. THE FREQUENCY WILL BE CHANGE AT 9 OCTOBER ABOUT 22:00 GMT. 73. CDR VALERY. RZ3FK

Packet operators reported that they were still hearing the ISS on its usual 145.800 MHz frequency on 09 October 2002. Many said they were monitoring both frequencies (145.800 MHz and 145.825 MHz) since the change could take place at any time over the next few days. The crew has been active with voice contacts also.

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